AIR PUBLICATION 1354
Revised, February, 1936
Reprinted, November, 1939
incorporating A.L.s 1—6

AIR PHOTOGRAPHY

Organisation and Training

Issued for the information and guidance of all concerned

By Command of the Air Council

AIR MINISTRY

LONDON
PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
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The Amendments promulgated in the undermentioned Amendment Lists have been made in this publication :—

Amendment List.		Amendments made by.	Date.
Number.	Date.		
1—6	—	Included in this revision.	—

AIR PUBLICATION 1854
(*Issued February, 1936 with A.L. 3*)

CONTENTS

CHAPTER IV—*continued*

PART II

FLYING FOR AIR SURVEY

CHAPTER V

AIR PHOTOGRAPHY IN CO-OPERATION WITH THE ARMY

CHAPTER VI

AIR PHOTOGRAPHY IN CO-OPERATION WITH THE ROYAL NAVY.

CHAPTER VII

INTERPRETATION OF AIR PHOTOGRAPHS

CHAPTER VIII

TRAINING PHOTOGRAPHIC PERSONNEL

CHAPTER IX

PHOTOGRAPHIC TRAINING OF FLYING PERSONNEL

APPENDICES

Chapter I
of
AIR PUBLICATION 1354
(*Issued February*, 1936 *with A.L.* 3)

CHAPTER I

THE PURPOSE AND VALUE OF AIR PHOTOGRAPHY

Introductory

1. One of the primary duties of the Royal Air Force when co-operating with the Navy or Army is reconnaissance. The use of aircraft has greatly increased the power of a commander to discover the intentions of his opponent and to keep himself informed of the movements and activities of the opposing forces. But visual observation, as a means of obtaining information, suffers from certain inherent limitations, and these are more especially marked when such observation is made from the air. It has been proved, however, that air photography is of inestimable value in compensating to a great extent for the deficiencies of the human eye, and the successful development of the air camera has vastly increased the scope of air observation.

2. During the war of 1914–18, when air photography was still in the experimental stage, it provided ample and increasing proof of its usefulness for military purposes. Since then the continued development of apparatus, equipment, and technique has resulted in considerable improvements in the quality of the photographs which can be obtained, and although much may still be done to improve the technical efficiency of the work, air photography to-day is an almost indispensable adjunct to air reconnaissance.

The Eye and the Camera

3. In considering the relative powers of each, it is not intended to suggest that the camera is an efficient substitute for the eye, or that it can ever replace it, but a brief comparison of their capabilities will show that the air camera constitutes an invaluable means of supplementing and confirming all which can be seen by the eyes of an observer.

4. In the first place the eye has a wide field of vision, but only as a result of movement. It can cover an enormous area in a very short space of time, but if it is desired to examine any part of a landscape in detail it is necessary to concentrate the eye on the selected objects in turn and thus risk missing something which is not included in the concentrated field of vision. Further, no human observer could record or remember more than a small fraction of the details seen during the flight.

The camera lens, on the other hand, records instantaneously and permanently everything within its angle of view, and the detail on the resultant photograph can be studied at leisure and information extracted therefrom under quieter conditions than those which obtain during flight.

5. Again, the scale of the landscape seen by the eyes from an aircraft is determined by the height of the aircraft, and no adjustment can be made to the eyes to compensate for increased height. Binoculars and telescopes are artificial aids for increasing the scale, but owing to the speed of modern aircraft, and to flying conditions generally, they cannot be used satisfactorily by an observer. By the use of different lenses of varying focal lengths, however, the scale of air photographs can be altered to meet any requirements, and within certain wide limits practically any scale can be obtained irrespective of the height at which the photographs are taken.

6. The colour-correcting powers of the eyes are insufficient at high altitudes and long ranges such as those suitable for reconnaissance, with the result that the landscape is normally viewed practically in monochrome, but by placing suitable light filters in the camera lens the contrasts may be strengthened, and a view which may appear flat and dull to the eye may be recorded in the photograph with far greater contrast.

7. The view of an observer in the average aircraft is greatly restricted by portions of the fuselage and the planes, and the only way in which he can obtain an uninterrupted view of the country below is by looking through an aperture in the floor. For obvious reasons it is impossible for him to do this continuously throughout the whole of a flight, but it is a comparatively simple matter to place the camera in such a position that a photograph can be taken at any given moment by merely working a lever or switch.

8. In addition to the foregoing comparisons, it must be realised that the eyes are adversely affected by fatigue, glare, ill-health, and very largely by imagination, while a purely mechanical device such as a camera is susceptible to none of these.

9. Finally, consider the difference in the task of an observer who is being flown over an occupied area at a considerable height, first without a camera, and secondly with a camera fitted in the aircraft. In the first case the observer watches the ground below until he locates some feature of an unusual character. He immediately makes a note, but in doing so temporarily removes his gaze from the object. On looking up he probably finds some difficulty in locating it again, and then while he is studying it the movement of the aircraft causes it to be obscured again by one of the planes. In

similar circumstances, but with a camera available, the observer sights an object, guides the pilot over it, and takes a photograph. By doing so he instantly obtains a permanent record of the objective, its exact location on the map, and definite confirmation of his own observations.

The Uses of Air Photography

10. The uses of air photography for military purposes are threefold, and may be broadly classified as follows :—

(i) The provision of military information regarding the enemy and his territory.

(ii) The provision of permanent records of the results of operations.

(iii) The production of military maps.

11. *Types of military information obtainable.*—The information which can be obtained by the study of air photographs may also be divided into three classes. The general nature of each type is given below :—

(i) *Strategical.*—Signs of military activity, or the absence of it, in definite areas. Occupation of territory. Concentrations of troops. Movements of large forces. Details of communication and supply systems. Formation of camps, depôts, dumps. Demolitions in back areas.

(ii) *Tactical.*—Details of enemy works such as trenches, barbed wire defences, battery positions, machine gun posts, tank traps, aerodromes, coastal defences, etc.

(iii) *Topographical.*—The shape and extent of woods, hills, valleys and lakes. The courses of rivers, nullahs, etc., and the nature of their banks. The position of bridges and fords. The position, shape, and size of towns and villages. The nature of coast-lines, and the position of navigable channels.

12. *Records and reports of operations.*—For the purpose of obtaining records and reports of the results of operations such as air bombardments, artillery fire, etc., air photographs are more accurate than visual observation owing to the fleeting nature of the objectives. Not only can valuable information regarding the result of such attacks and the amount of damage inflicted be obtained from air photographs taken after the event, but the degree of success attained can be estimated with the minimum of delay, and with a reasonable amount of accuracy, from photographs taken during the actual operations. For this reason it is customary to include at least one aircraft fitted with an air camera in each flight engaged on day bombing operations.

13. *Production of Maps.*—(i) It is unlikely that air survey, carried out with a view to the preparation of accurate maps, will be possible over an area organised for A.A. defence, nor is this necessary when suitable maps already exist. Nevertheless from the data obtained from air photographs, existing maps can be brought up to date and improved, and any alterations and additions necessitated during the course of operations may be made with the utmost rapidity.

(ii) Photographic mosaics are of great value for military purposes in unmapped, or badly mapped, regions, and although liable to a certain degree of distortion they are sufficiently accurate to be of the greatest assistance in planning the movements of troops through such territory.

(iii) Large-scale prints of individual air photographs, especially oblique views, are frequently very useful for familiarising unit commanders with the terrain over which they will be required to lead their men, and of which but a vague idea of the chief characteristics can be obtained from a map.

The objects to be attained in Air Photography

14. The two primary objects which must always be aimed at in the conduct of air photography in the Royal Air Force are :—

(i) Critical definition.

(ii) Speed of production of the finished print.

15. The value of an air photograph entirely depends on the amount of useful information which can be obtained from it, and this in its turn depends very largely on the quality of the photograph itself. Photo-reading consists largely of the study of shapes and shadows, and however skilful and experienced the reader may be, it is necessary for the print to contain a sharply defined image and the maximum amount of detail if he is to succeed in extracting the greatest amount of information from it. The better the quality of the photograph, the easier and the more rapid and accurate is the work of the reader; while a blurred and indistinct image not only increases the difficulty of his task but is also liable to cause him to make incorrect deductions.

16. The other object, speed of production of the finished print, requires little explanation. The degree of usefulness of almost every form of military information is in inverse proportion to the length of time required for it to reach its destination. A photograph which revealed the preparations for an unexpected movement on the part of the enemy would be of the utmost value to the commander and staff concerned if they received the information thus disclosed in good time, but such a photograph would be quite useless if it was not

produced until some hours after the threatened attack or retirement had taken place. It must be remembered that after the photograph has been produced by the Royal Air Force, a further period of time is still required before the work of interpretation can be completed by the army, and it is therefore of vital importance that the prints should be issued with the minimum of delay.

17. The photographic equipment and apparatus used by the Royal Air Force is designed with a view to assisting as far as possible in the attainment of these two objects, and it is therefore necessary that the work should be so organised, and that the training of the personnel employed on photographic duties, both on the ground and in the air, should be such that the greatest advantage is derived from the use of this equipment and apparatus, and that there should be the least possibility of failure in those operations in which the human factor predominates.

Method of Attainment

18. The only method by which a completely efficient photographic service can be maintained is by ensuring that the personnel concerned receive a sound initial training, and that they are afterwards given constant practice in their various duties. Those concerned may be divided into two classes, i.e., the flying personnel who are responsible for actually taking the photographs from the air, and the technical photographic personnel whose duty it is to ensure that the preparation of the camera and equipment before the flight is efficiently carried out, and who are responsible for the production of the finished prints from the plates and films exposed during the flight.

19. Beyond a knowledge of the principles of camera installation, the ability to supervise the mounting of cameras in aircraft, and sufficient knowledge of camera mechanism to enable them to remedy simple faults, the flying personnel require no technical photographic knowledge, and for successful photographic flying a pilot requires no special qualifications other than those which he obtains during his training for normal flying duties. The ability to fly level on a straight course for fairly long periods, and to fly vertically over a given point on the ground, can only be attained by constant practice but it is within the capabilities of every service pilot, provided that he is given sufficient opportunities for such practice. If, therefore, the pilot is capable of accurate flying, and the passenger possesses sufficient elementary knowledge of the mechanism to operate it successfully, the camera will do all that is required as far as the actual taking of the photograph is concerned. Nevertheless, it must be borne in mind that

the cost of the photographic materials expended in producing a set of air photographs is very small compared with the flying costs involved, and that, under war conditions, the lives of the flying personnel are an important consideration. Moreover, as has already been pointed out, the value of an air photograph depends very largely on the speed with which it can be produced, and it is very seldom either possible or justifiable to undertake a second flight, with the consequent additional cost, risk, and delay, with a view to compensating for an initial failure. It is, therefore, of vital importance that all pilots who are required to undertake photographic flights in the course of their normal duties, should be given ample practice in this type of flying, and that all observers and air gunners should be made perfectly familiar with the operation of the various types of cameras used. Squadron commanders and photographic instructors must ensure that the ground and air practices laid down in Chapters VIII and IX of this manual are properly carried out, and that the personnel concerned become thoroughly proficient.

20. Although the actual exposure of the plate or film is the first essential step in the production of an air photograph, it is by no means the most difficult one. The various operations which precede and follow it call for a considerable degree of technical knowledge and skill, and are fraught with many different possibilities of failure. The photographic personnel responsible for these operations receive their initial training at the School of Photography, and in order to pass the course successfully they are required to attain a high standard of knowledge and proficiency. But practice and experience are as essential for thorough proficiency as theoretical knowledge, and unless the officers and airmen concerned are given ample opportunities for carrying out their technical duties after posting to service units, the high standard of work required cannot be maintained. At times when the amount of photographic work being carried out by the unit is small, every effort should be made to provide frequent practice tests for airman photographers.

21. As regards the two main objects to be attained, the technical quality of photographs depends chiefly on the care with which the cameras, equipment, and apparatus are adjusted and used, and on the skill with which the various operations such as loading magazines, developing, printing, enlarging, etc., are carried out. It is, therefore, primarily a matter of individual proficiency. Speed of production of the finished print is more a matter of organisation, and under no circumstances can it be secured by haphazard methods of working. It is the duty of every warrant officer or N.C.O. in charge of a unit photographic section to be constantly on the watch

for means of improving the organisation of the work, and to ensure that every operation, including practice, tasks and those of a comparatively unimportant nature, is carried out with the minimum of delay. He should at the same time be careful that the highest possible standard of work is maintained, and should never pass results which fail to reach this, or neglect to investigate reasons for such failures.

22. Chapter III of this manual contains the general instructions for the organisation of photography in a unit. A.P. 1355, Photographic Equipment Manual, Vol. I, includes full details regarding the correct methods of carrying out the various photographic processes. Both of these should be carefully studied and the provisions invariably adhered to by all those actively concerned.

CHAPTER II

GENERAL ORGANISATION

Chain of responsibility

1. The chain of responsibility for the organisation of air photography is as follows :—

(i) *Air Ministry*.—(*a*) Policy and Organisation are dealt with by the appropriate branches in the Departments of the Chief of Air Staff, and of the Air Member for Supply of Organisation, there being a photography officer in the Directorate of Operational Requirements.

(*b*) Research and Development are the responsibility of the Department of the Air Member for Development and Production, there being a photography officer in the Joint Directorate of Research and Development.

(*c*) Training is the responsibility of the Department of the Air Member for Personnel, there being a photography officer in the Directorate of Training.

(ii) *Commands*.—An officer, designated the " command photography officer," is appointed to the staff of each air officer commanding a command, and is responsible for the organisation of air photography in the command.

(iii) *Groups*.—An officer, designated the " group photography officer," is appointed to the staff of each group commander whose command includes units which carry out air photography. The officer is responsible for the organisation of air photography in the group.

(iv) *Units*.—A warrant officer or senior N.C.O. who has passed an instructors' course at the school of photography is posted to every squadron or independent unit which is required to carry out photography. In the case of stations normally occupied by two or more squadrons where photography is organised on a station basis, such a warrant officer or N.C.O. is posted to station headquarters.

Chapter II

It is the duty of all unit and formation commanders to organise, in conjunction with their photography officers or photographic instructors, the photographic work of the unit, or formation under their command, on the lines laid down in this Manual, and with any other instructions which may be issued from time to time. This does not, however, absolve commanders from improvising the best arrangements possible when the authorised means are not available.

Responsibility for New Design

2. Photographic research and experimental work in connection with new design of cameras and photographic equipment is carried out at the Royal Aircraft Establishment.

3. Photography officers, photographic instructors and C.O.'s of units, who, through practical experience, consider that any modifications or improvements could be made to existing designs of cameras and photographic equipment with a view to fulfilling service requirements, should submit their suggestions through the usual channels.

Responsibility for Supply

4. The Director of Equipment is responsible for the provision of photographic equipment, with the exception of permanent buildings and constructional fittings supplied by the Directorate of Works and Buildings.

5. The supply of cameras and photographic equipment to units will be made in accordance with the provisions of Air Publication 830, Vol. III.

Responsibility for Repairs

6. C.O.'s of units which hold cameras and photographic equipment on charge are responsible that all such articles of equipment which becomes unserviceable are dealt with in accordance with the regulations.

7. The procedure for effecting repairs is laid down in Air Publication 830, Vol. I, and in Air Ministry Orders.

Chapter III
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CHAPTER III

ORGANISATION OF PHOTOGRAPHY IN A UNIT

Photographic Sections

1. Photographic sections are organised in time of peace on either a squadron or station basis. The photographic section of a squadron or an independent unit may be organised either as a permanent or as a mobile unit, according to circumstances and to the type of accommodation available.

2. *Permanent Sections.*—(i) At all permanent stations, at home and abroad, normally occupied by one or more squadrons which carry out air photography, a specially designed building will be provided for photographic purposes. Such a building will include dark room, work room, office, and storage accommodation, and should, under no circumstances, be used for any other purpose than that for which it is designed.

(ii) In certain formations, photographic sections will be organised on a station basis. Where this is done, all ground work in connection with air photography will be carried out at the station photographic section under the control of the photographic instructors. This section, which will occupy permanent accommodation, will take the place of squadron sections for all normal purposes. The organisation of station photographic sections should be in every way similar to that of squadron sections, and, except where it is otherwise stated, the instructions contained in this chapter will apply equally to both.

3. *Mobile Sections.*—(i) All squadrons and independent units which are organised on a mobile basis, and which are required to carry out air photography as part of their normal service employment, are equipped with a photographic lorry and trailer. These vehicles provide adequate dark room accommodation for all normal purposes, and are also capable of transporting the entire squadron photographic equipment. They thus constitute a satisfactory means of carrying out the necessary ground work when the squadron is operating away from a permanent base, either in course of training or on active service, or on occasions when no other more suitable accommodation is available.

(ii) When the squadron is situated at an aerodrome where a permanent building is available, the photographic lorry and trailer should not be used for normal work. As, however, the working space in these vehicles is considerably more restricted than that afforded by a specially constructed building, the personnel of the section must be given adequate practice in working in them, in order that no loss of efficiency may result when they are brought into use.

(iii) Photographic instructors should be prepared, when operating in the field, to adapt local facilities to their needs, and to establish dark-rooms, printing rooms, etc., in any premises which may be available and which lend themselves to this purpose. In selecting accommodation for photographic purposes, attention should be paid to the following factors :— temperature, ventilation, humidity, water supply, electricity supply of suitable voltage, and the ease with which the rooms may be made light-proof.

4. *Allocation of Photographic Duties.*—The allocation to officers and instructors of duties in connection with air photography are set out in Appendix I.

Employment of Personnel

5. In allocating duties to the personnel of the photographic section, special care should be taken to avoid any large degree of specialisation. It will be found that many airman photographers are apt to be more proficient in one branch of their work than in another, and to show a marked preference for that particular type of work. Thus, an airman who excels at development, but whose printing and titling is poor, is liable, owing to his proficiency in, and liking for, such work, to be continuously employed on developing. This state of affairs must be carefully guarded against, for if specialisation is permitted, when cases of sickness or absence occur the general efficiency of the section as a whole will be seriously affected. The object to be aimed at is to attain a high standard of proficiency throughout the section in all branches of the work, and with this end in view the duties should be arranged so that the nature of each man's employment is frequently changed, and that airmen are given constant practice in those duties in which they show the least proficiency.

6. Speed of production of the finished prints being one of the primary essentials in photographic work in the field, it is the duty of the unit photographic instructor to devote constant thought to the problem of how this may be attained. The actual periods of time required for the various chemical processes cannot be altered, and the technical perfection of the work must never be sacrificed for increased speed, but there

are other factors which have a great bearing on the time taken to procure a given result. The greatest delay occurs in passing films, printing paper and materials from one operator to another between the various processes, and every minute, or every second, which can be saved by improving the organisation is of value. An efficiently organized section is one in which every man, every piece of equipment, and every piece of material, is in the right place at the right time, so that the work proceeds at the maximum speed and with the minimum confusion.

7. Personnel employed in dark rooms must be relieved at frequent intervals. The restricted means of ventilation, which is due to the necessity for keeping the room light-proof, causes the temperature to rise and the air to become foul. This gives rise to headaches and other adverse effects to the health of the operators if they are kept working too long under such conditions. The longest period during which an airman working at high pressure can remain in a dark room without discomfort is approximately 2 hours. This varies considerably with the climatic conditions, and is much less in hot countries. Every opportunity must be taken to open all doors and windows in the dark room to admit fresh air.

Position of Photographic Section

8. In peace time, at a station where a permanent building is erected for the use of the photographic section, the site will be fixed after consultation with the Directorate of Works and Buildings. When conditions are such that temporary accommodation has to be selected, or the photographic lorry and trailer employed, the decision as to the most suitable site will rest with the C.O. and the unit photographic instructor.

9. The three primary factors in determining the most suitable location for the section are as follows :—

(i) Proximity to the aerodrome and hangars.
(ii) Adequate water supply.
(iii) Electricity supply of suitable voltage.

10. When there is any doubt as to which of two or more possible sites should be selected, the relative advantages of each under (i), (ii) and (iii) must be compared, and the one which affords the greatest saving of time and labour in communication and transport should be chosen.

Storage of Cameras and Equipment

11. (i) All cameras and equipment should be kept by the photographic section. Cameras not required for use may be kept in unit stores. Cameras should not be left in charge of flights.

(ii) Cameras, and camera fittings, should be kept in the storage cases in which they are issued.

(iii) Cameras, camera mountings, and mechanical equipment generally should be stored separately from chemicals and photographic apparatus.

(iv) Cameras and equipment should be returned to the section as soon as possible after use in the air, and in any case before the end of the day's work.

(v) In every photographic section a register should be kept showing particulars of all cameras and equipment on charge and details of all daily issues and returns to and from flights.

(vi) Cameras and equipment must be kept clean and free from dust. The inspections laid down in para. 16 of the chapter should be carried out even if the cameras are not used. Camera log books as laid down in para. 29 must be kept up to date.

Installation of Cameras and Equipment in Aircraft

12. Whenever a camera is fitted the airman responsible for the airframe must be informed. If the electrical system of the aircraft is to be utilised to operate the camera the flight W/T personnel must also be informed. The actual work of fitting or removing the camera will be carried out by a photographer or qualified air gunner. When demanding the camera, Form 2052 should be used.

13. All cameras and equipment should be tested before leaving the section in order to ensure that they are in proper working order. When such equipment is required for use in the air, it will be conveyed to, and fitted in the aircraft by a photographer or qualified air gunner detailed for the purpose. The camera struts must be level and in the correct position for the particular lens to be used. The mounting must be examined to see that adjustments for levels and drift can be made freely. After installation the camera must be tested. This test should consist of carrying out several complete cycles of operation with the camera. Care must be taken to ensure that all surplus lengths of leads are secured and do not interfere with any controls; that the flexible drive has no sharp bends or kinks in it and does not touch the camera or mounting except at the bayonet joint, that the Bowden cable of the mechanical release works freely and is correctly adjusted, and that the field of view of the lens is not obstructed in any way. Adjust the counters on the electrical and mechanical controls to zero.

F.8 and F.24. Cameras.—Test camera on hand operation. Connect camera up for method of operation to be employed. Carry out several cycles of operations before fitting magazine.

Fit magazine and carry out two complete cycles of operations to remove fogged exposures and ensure that magazine is working correctly and not fouling the meshing lever. (F. 24).

14. Arrangements should be made for a photographer from the section to be available whenever an aircraft which has been carrying out air photography returns. It is desirable that the airman who fitted the camera before the commencement of the flight should be detailed for this duty. As soon as possible after the aircraft has landed he should take charge of the exposed magazines and return them to the photographic section. He should also obtain a brief report from the operator regarding the working of the camera. If this has been satisfactory and the camera is not required for further work in the air he should remove it from the aircraft, and return it together with the camera mounting and other fittings, to the section. In the event of any failure or faulty working being reported, he should carry out a brief inspection of the equipment before removing it from the aircraft, with a view to ascertaining if such failure has been due to faulty installation. If this does not appear to be the case, he should return the camera at once to the section for a thorough examination.

Repair of Cameras and Equipment

15. Personnel of photographic sections are not allowed to attempt repairs other than those detailed in para. 16.

16. The following repairs only may be carried out by unit photographic sections :—

(i) " *P.*14 " and " *P.*18 " *Cameras.*—Fitting of :—
Daylight Loading Slide.

Note.—Under no circumstances should any attempt be made to effect repairs to any part of the shutter, plate changing, or gearbox mechanisms in any of the above cameras.

(ii) *F.*8 *and F.*24 *Cameras* :—

No repairs of any description may be attempted. Any unit containing a broken or unserviceable part will be returned to stores and a new unit drawn. Cameras will be cleaned and oiled as follows :—

(*a*) *At Home.*

1. *Weekly.*—Inspect and clean camera and lubricate the following parts :—
Worm and worm wheel.
Ball races at each end of worm.
Ball races at each end of flexible drive.
Locating lever cam.

2. *Monthly.*—Lubricate all bearings in camera gear box.

(*b*) *Overseas.*

The weekly inspection detailed above should be carried out after each flight, and the monthly inspection carried out weekly.

General.

Oil lubricating, general, anti-freezing (Section 34 Ref. No. 43) only should be used.

Cameras must be lubricated sparingly, care being taken to ensure that all electrical contacts and the armature of the solenoid are free from oil.

As far as possible, magazines and controls mechanical should be fitted to individual cameras and given the same series letter.

Storage of Sensitive Materials

17. *Plates and Paper.*—Photographic plates, and printing papers should be carefully stored under the most favourable conditions obtainable in order that they may be maintained in good condition.

18. Whenever possible such materials should be stored in a cupboard in a dry, well-ventilated room, and it is important that they should be kept remote from the place where the chemicals are made up. Boxes of plates, and packets of bromide paper should invariably be stored on edge and never stacked flat one upon the other. If the latter practice is permitted, the pressure on the material at the bottom will result in " stress " marks and render it unfit for use.

19. In order to avoid the possibility of wastage of plates when opening a box from which the entire contents are not immediately required, the following procedure should be adopted. The outside paper wrapper should be scored through the centre on all four sides so that it may be removed in two sections. When the required number of plates have been withdrawn the two halves of the wrapper should be replaced over the box and joined round the centre with paper and paste, or with passe-partout binding strips. The contents will thus be protected from accidental exposure to light, and the reference as to the type of plates retained.

20. Should the premises in which the sensitive materials are stored be at all damp, provision should be made for raising the cupboard containing them above the level of the floor and for keeping it from contact with the walls.

21. *Films.*—All tins containing film should be stored in an iron locker, fitted with iron shelves. The locker should be situated in a dry, well ventilated room. It must not be near a fire or radiator or in a wooden building. Films must be stored away from chemicals.

Exposed films must always be kept in their tins. Each tin should be numbered and the tins stored in the same manner as those containing unexposed films. A special metal container marked, " Celluloid Waste " in red, must be kept for all waste films. Fire extinguishers and a damp blanket must be available in any room where film is stored. *See also* A.P. 830, Vol. II, Leaflet G.10.

21A. The photographic instructor should regulate the issue of sensitive materials in such a manner as to ensure that those which have been longest in stock are used up before new supplies are brought into use.

Storage of Chemicals

22. Most of the chemicals employed in photography will remain in good condition for long periods if properly stored. They should be stored in a cupboard in a dry, well ventilated room and must be stored away from sensitive materials and equipment. Attention will also be paid to the following points :—

(i) All bottles containing poisonous chemicals should be kept well stoppered or corked, as the case may be. This is of vital importance with chemicals which oxidise readily, or are of a deliquescent nature.

(ii) Bottles containing chemicals in crystals or in powdered form must not be allowed to stand about in dark rooms or work rooms.

(iii) All chemicals should be kept in a locked cupboard, the key of which should be held by the N.C.O. in charge of the section. The N.C.O. in charge will issue chemicals as required for the preparation of solutions and any partially emptied bottles should be returned to him immediately after the required amount of the contents has been used.

(iv) The N.C.O. in charge should regulate the issue of chemicals in such a manner as to ensure that those which have been longest in stock are used up before new supplies are brought into use.

Marking, Registration, Filing, Custody, and Storage of Negatives

23. The regulations governing the marking, registration, filing, custody, and storage of both plate and film negatives are contained in A.M.O. A.208/37, and in A.P. 1355, Vol. I, Part I, Chapter 16.

Chapter III

Records to be kept

24. The following records should be kept by every photographic section :—

(i) Negative Registers. R.A.F. Form 2052.

(ii) Film, plate and paper consumption record. R.A.F. Form 2048.

(iii) Camera log books. R.A.F. Form 2050.

(iv) Training record.

(v) Reconnaissance reports. R.A.F. Form 2047.

(vi) Work book. R.A.F. Form 2045.

(vii) Record of photographic flights. R.A.F. Form 2051.

25. *Negative Registers.*—To be kept as laid down in A.M.O. A.208/37.

Film Plate and Consumption Record. R.A.F. Form 2048.

26. In peace-time a record should invariably be kept showing the supplies of sensitive materials received and the quantity expended on each task. R.A.F. Form 2048 is to be used for this purpose.

27. All boxes of plates, rolls of film, and packets of printing paper should be numbered as they are received in the photographic section. These reference numbers, together with the date of receipt, will be entered in the " IN " columns on the appropriate pages. The quantity expended on each particular occasion, the purpose for which it was used, and the date should be entered in the " OUT " columns.

28. This record serves the following purposes :—

(i) It forms a check on the work of the section, and when examined in conjunction with the quality of the results produced, provides a record of the general standard of efficiency of the personnel in the various technical processes.

(ii) It prevents waste of sensitive materials, and enables any excessive consumption of stocks to be traced.

(iii) It provides a valuable record of information on which the unit photographic instructor can base his estimate of the quantity of materials required for any particular period, or purpose.

29. *Camera Log Books. R.A.F. Form 2050.*—A log book is to be kept for each camera.

The left-hand page will contain a record of all work done with the camera, and the right-hand page a record of all failures, replacements and inspections.

30. *Training Record and Chart.*—These will be kept as laid down in Chapter IX.

31. *Photographic Reconnaissance Reports. R.A.F. Form 2047.*—Reconnaissance reports will be kept on R.A.F. Form 2047.—A copy of the recconnaissance report should be kept with the film to which it refers.

32. *Work Book. R.A.F. Form 2045.*—All photographic work carried out by the section should be entered in the work book. Each job should be given a serial number and this serial number should appear in the consumption record in the column showing purpose for which material issued was required. A receipt form, R.A.F. Form 2046, should be made out and despatched with every batch of prints, etc., sent out by the unit. On their return receipt forms should be filed. The receipt form should be given the same number as the job.

33. *Record of Photographic Flights. R.A.F. Form 2051.*—This forms a complete record of all photographic flights, and includes details of exposures, etc. It also forms a record of camera issues.

CHAPTER IV

PART I

METHODS OF PHOTOGRAPHIC FLYING

(*Note.*—Photographic formulæ for calculation of scales, etc., will be found in A.P.1355, Photographic Equipment Manual.)

General Considerations

1. To obtain the best results in all types of air photography, it is necessary for all the personnel employed on photographic flying to have a good working knowledge of the methods found to be the most satisfactory and also of the fitting and operation of air cameras in service use. It is therefore essential that a short series of lectures on these subjects should be incorporated in the annual training programme of all the units concerned with air photography. During the course of training, in addition to the normal photographic work, arrangements should be made, when possible, for pilots to operate the photographic equipment in the air in order to appreciate difficulties; this will lead to closer co-operation of the crew and better work will result.

2. (i) Every form of air photography, with the exception of pin-point photography, calls for accurate air navigation. It is therefore essential that aircraft compasses should be swung carefully, and corrected for deviation as far as possible, also that the best instruments available should be used for finding drift and checking position. In this connection every opportunity should be taken, in suitable units, to use the course setting bomb sight, the tail drift sight, the Aldis camera aiming sight, or other similar instruments.

(ii) Some form of inter-communication is essential. Electric telephones are the most satisfactory, but speaking tubes may be used with success. Flying helmets must be closely fitting and the earpieces comfortable. A strap round the helmet arranged to pull the earpieces closely in to the sides of the head will be found of great assistance. Conversation in the air must be cut down to the minimum and words must be enunciated distinctly and slowly. Pilots must be able to fly straight and level for long periods and must exercise patience at seemingly unnecessary delay on the part of the camera operator. Aerobatics should not be carried out as the photographic equipment is liable to be damaged. All photographic equipment must be safely stowed away in the aircraft and if necessary lashed down. Pilots should be familiar with the

type of aircraft to be flown, as their minds must be free from any feeling of strangeness so that they may be able to concentrate on the many simultaneous requirements of a good photographic flight.

(iii) In all forms of photographic flying adequate preparations must be made on the ground before flight. The pilot must make himself thoroughly conversant with the details of the photographic requirements, obtain the necessary maps, and discuss the procedure to be adopted in the air with the camera operator (or air gunner, in army co-operation squadrons) and with the photographic instructor. The photographic section will be responsible for fitting the appropriate apparatus in the aircraft, which will be checked for correct working in the presence of the camera operator before handing over.

(iv) (*a*) As soon as possible after the aircraft has landed the camera operator should take the exposed magazines to the photographic section. He will render a report to the photographic instructor on the working of the camera. If this has been satisfactory, and the camera is not required for further work in the air, it should be removed from the aircraft and returned to the photographic section, together with the mounting and other fittings.

(*b*) In the event of any failure or faulty working being reported, the camera should be inspected by a photographer before being removed from the aircraft to ascertain if the trouble was due to faulty installation. If this is not the case, the camera should be returned to the section immediately and thoroughly examined.

VERTICAL PHOTOGRAPHY

3. Vertical photographs may be required for :—
   (i) Pin-points.
   (ii) Line overlaps.
   (iii) Mosaics.

Pin-points

4. *On the ground.*—(i) *Duties of Photographic Section.*—
   (*a*) Load the film or plates.
   (*b*) Fit the mounting and camera in the aircraft and test without magazine.
   (*c*) Set exposure.
   (*d*) Set counters to zero.
   (*e*) In the case of film cameras. Fit magazine and test camera in presence of camera operator or air gunner,
   or
   In case of plate cameras. Hand over magazines and test camera in presence of camera operator or air gunner.
   (*f*) Advise camera operator or air gunner as to exposure set.
   (*g*) Hand over.

(ii) *Duties of Pilot.*—

(*a*) Obtain details of photographic requirements (including height from which photographs will be taken) and mark on map if appropriate.

(*b*) Discuss with camera operator, or air gunner and the photographic instructor the procedure to be adopted in the air.

(iii) *Duties of Camera Operator or Air Gunner.*—

(*a*) Obtain details of photographic requirements and discuss procedure to be adopted in the air with the pilot.

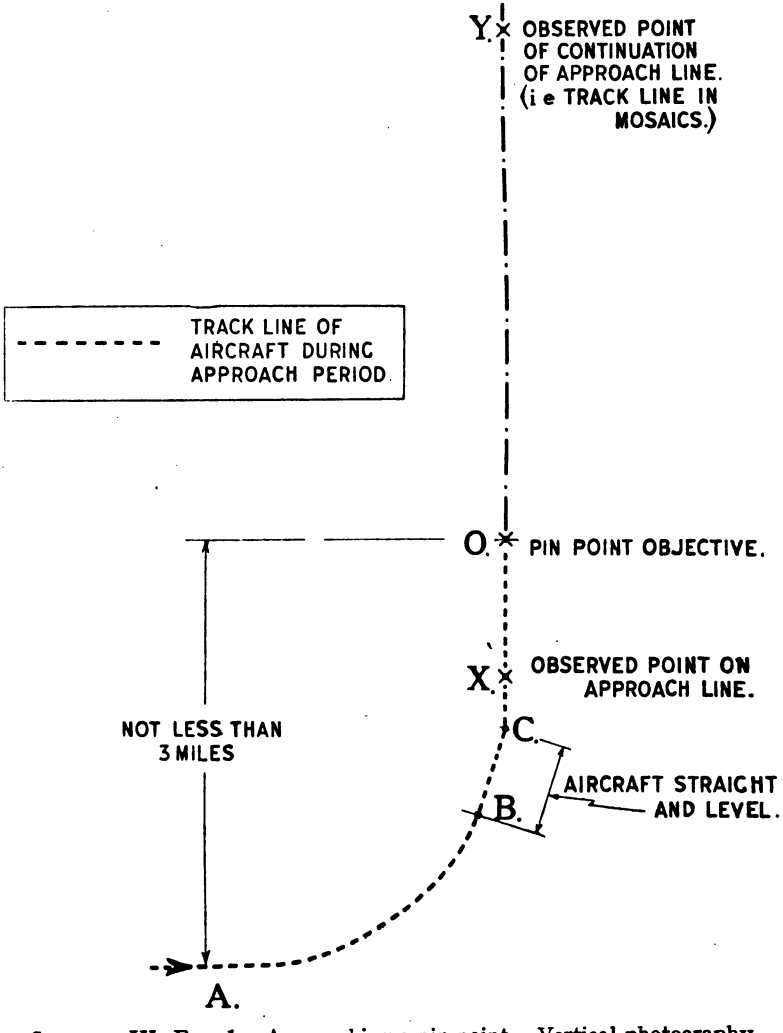
(*b*) See camera tested by photographic personnel and check exposure set.

(*c*) Take over photographic equipment.

(*d*) Obtain and fit any air navigation instruments to be used.

5. ***In the Air.***—(i) For the photography of pin-points the pilot is primarily concerned with flying the aircraft so that it will pass vertically over the objective. On arriving at the selected height and before approaching the objective, the pilot should set his throttle and tail actuating gear so as to fly level and at a fixed cruising speed. The camera in its mounting should then be levelled. The pilot must ensure that this trim of the aircraft is maintained at the moment of all subsequent exposures, or that the camera is relevelled if necessary. In this connection it should be noted that movements of any member of the crew in the aircraft will have the effect of altering the trim. The camera operator or air gunner must be careful therefore that he is in the same approximate position during the levelling operation as for subsequent photography.

(ii) The following procedure has been found satisfactory to enable the aircraft to pass vertically over the pin-point (*see* fig. 1). Having identified the pin-point (O), two suitable landmarks on the proposed line of approach should be chosen one (Y) on the far side of the pin-point (as far away as possible) and the other (X) on the near side. The aircraft should then be flown at right angles to the proposed line of approach and not less than three miles " back " from the pin-point. Before the two guide points (X and Y) and the objective (O) come in line with the pilot's line of sight, a slow steady turn (at A) should be commenced towards the pin-point, which will bring the aircraft to a position (B) where the three points, visible to the pilot, are still not quite in line with the pilot's line of sight but the aircraft is pointing within 5–10 degrees of the correct course for passing over the objective. This course



CHAPTER IV, FIG. 1.—Approaching a pin-point. Vertical photography.

APPENDIX IV

SPECIMEN NAVIGATION PRINTS FOR USE IN THE AIR

Area 12 Run "F"

Explanation

Note.—In actual practice there will be normally at least 3 navigation prints per "run" as shown in this specimen.

Particulars Given

1. Total number of exposures in run.
2. Number of exposures between "controls".
3. "Control" points (centre of circle on each print).
4. Theoretically correct track line.
5. Truercourse for running in either direction.
6. Maximum permissible error lines on either side of track line. It has been found in practice that it is desirable to have these lines inside the 30 per cent. maximum permissible error position (if the prints are of the same scale as is proposed for the filling-in strip run, then 30 per cent. error positions will be 2·1 inches. In this example they have been closed in to 1·9 inches).

If it is known that on the adjoining strip an error has been made, causing the lateral overlap to be endangered, then the position of the appropriate track line should be moved in to conform.

(50253)

should be maintained until a point (C) is reached in the air where the three points are in line with the aircraft. A minor turn is then made on to the correct course.

The advantage of this method is that no violent swirl is set up in the compass bowl, and therefore the final " steady " on to the correct course will be easy and accurate.

(iii) Another method favoured by some pilots is to fly at right angles to the approach line and two or three miles " back " from the pin-point as before, but to wait until the three points are coming in line before turning. A rapid " turn on " is then made and the aircraft steadied by observation of the distant landmark. The advantage of this method is that a certain amount of time is saved, but it suffers from the disadvantage in that compass swirl is set up. It should only be used by pilots experienced in photographic flying.

(iv) After the aircraft has been steadied on the approach line by one of the above methods, final corrections will be made as follows.

In the case of army co-operation squadrons where the pilot is responsible for making the exposure, minor corrections will be made with the aid of the pilot's camera sight, or, if this is not fitted, by sighting through the trap door in the bottom of the fuselage. In the case of units where a separate camera operator makes the exposure, he will assist the pilot during the approach period, giving a " left " or " right " correction if necessary. The pilot will respond by making an " S " turn in the appropriate direction. The exposure will be made when the camera is judged to be vertically over the objective. The line of approach should be made up wind when practicable, as fewer corrections will be found to be necessary.

Note.—The above described procedure is equally applicable when approaching a " start point " for a photographic strip flight, in which case the necessity of getting on to and maintaining a correct compass course is of extreme importance.

General Considerations affecting Flying for Consecutive Vertical Photographs

6. Before discussing the detailed methods of flying for line overlaps, or mosaics, it will be necessary to consider certain general factors which are relevant to all forms of consecutive vertical photographs. The best results will be obtained when the following conditions are fulfilled :—

(i) Aircraft flown on a straight course.

(ii) Correct fore-and-aft overlap.

(iii) No tilt in any direction.

(iv) Constant height.

(v) Making good a given track.

7. *Aircraft flown on a Straight Course.*—It is essential to maintain a straight course while flying for all forms of vertical photographs. The methods of doing this with standard service equipment are as follows :—

(i) By means of an accurate compass.

(ii) By means of a turn indicator.

(iii) By flying straight at some part of a distant cloud or distant object on the ground.

(iv) By keeping the shadow of some object on the aircraft in a constant position.

(v) By following a straight line, such as a railway, and keeping a mark on the leading or trailing edge of the lower plane on this line.

It is found that the most satisfactory results are obtained by flying on a compass course, corrected for drift, using, in conjunction, a distant cloud, where possible.

8. *Correct Fore-and-aft Overlap.*—The fore-and-aft overlap is usually determined by the requirements for stereoscopic examination of the prints ; for this purpose an overlap of 60 per cent. is required and this figure is therefore taken as the standard overlap in the Royal Air Force. Further, if for any reason one exposure of the series fails, the resulting photographic strip is still continuous.

9. It will be necessary first to decide upon the height from which the photographs are to be taken. The height necessary to obtain any scale required can be worked out by means of a suitable formula. The time interval between exposures to obtain the required fore-and-aft overlap at this height can be calculated if the air speed of the aircraft, wind speed, size of negative, and focal length of lens are known. This calculation can be checked as follows :—Measure the distance between two points on a map ; calculate the number of exposures with correct overlap required to cover this distance. Then when at the determined height, find the time taken to fly between the two points. This time, divided by the number of exposures with correct overlap, will give the time interval.

10. *No Tilt in any Direction.*—Tilt may be either fore-and-aft or lateral and may be due either to incorrect levelling of the camera mounting, or to the fact that the aircraft is not upon an even keel at the moment of exposure. The effect of tilt is to cause variation in the scale over the photograph, thus giving distortion. The intended area for the exposure also will not be completely covered and variation in overlap, even to the extent of gaps being caused, may result.

11. *Levelling the Camera.*—Upon reaching the pre-determined height, the engine must be throttled down to the normal

cruising speed, and the aircraft trimmed to fly straight and level. The tail actuating gear, radiator shutters, etc., should be adjusted. The camera should then be levelled for this particular trim of the aircraft. It is of the utmost importance that the trim should not be altered during the runs. If it becomes necessary to adjust the throttle during the run, the fore-and-aft trim may thus be altered, and it will then be necessary to re-level the camera. It is of great importance that the rigging of the aircraft should be as accurate as possible, but should there be a tendency to fly one wing low, it is better to correct the effect by means of the camera levelling screws than to attempt correction by means of the control column.

12. Any tilt obtained, which is not due to incorrect levelling of the camera, must be caused by a temporary displacement of the aircraft fore-and-aft or laterally. If the rules for "Aircraft flown on a straight course," laid down in para. 7, are observed, the pilot should notice any rise or fall of the nose of the aircraft and check it instantly. Lateral displacement must be checked by reference to the cross level and also by a quick glance along the wings from time to time to ensure that they are horizontal. Marks on the outer struts, or a wire across the centre section struts can also be used. These will indicate the approximately correct position of the horizontal from the pilot's cockpit.

13. *Constant Height of Aircraft.*—Change of height of the aircraft will cause difference in scale between consecutive photographs, and this, under some circumstances, may render the photographs useless. In all cases it will give the ground staff extra work and trouble, and is likely to cause confusion. Change of height of ground will, of course, also cause the scale to alter, but no allowance for this will be made during photographic flying. For average service conditions the altimeter reading will be satisfactory to assist in maintaining a constant height. The air speed indicator, the engine revolution counter, a statoscope, or a pitch azimuth indicator are all of assistance in maintaining a constant height.

14. *To make good a given Track.*—It is convenient to deal with the various methods available under two separate headings :—

(i) The pilot and air gunner (where the air gunner takes no part in the air navigation or operation of the camera, as in army co-operation squadrons).

(ii) The pilot and camera operator (where the camera operator assists the pilot with the air navigation and also operates the camera).

15. *Pilot* (acting as camera operator) *and Air Gunner* (where the air gunner takes no part in the air navigation or operation of the camera, as in army co-operation squadrons).

(i) *When Maps are Available.—On the Ground.—*

(*a*) Identify on the map the track to be flown.
(*b*) Determine the magnetic bearing of the track.
(*c*) Ascertain the estimated wind speed and direction at photographic height from such meteorological sources as are available.
(*d*) Work out with the aid of a course and distance calculator the magnetic course to be flown.
(*e*) Ascertain the deviation for the aircraft concerned and note the final compass course.

(ii) *When Maps are Available.—In the Air.—*

(*a*) While climbing to height, identify and study the track line.
(*b*) On reaching photographic height adjust the aircraft to fly " hands off " at cruising speed.
(*c*) Pass vertically over the starting point on the calculated compass course (*see* para. 5).
(*d*) Note, by looking through the pilot's camera sight or through the trap door in the bottom of the fuselage, if the track made good over the ground coincides with the required track. If the two tracks coincide return to the starting point ready to commence photography.
(*e*) If the two tracks do not coincide, note the divergence on the map and make a suitable correction to the compass course. The amended compass course will now enable the aircraft to be flown along the required track.
(*f*) In making the test run, it is not essential that the pilot should pass absolutely vertically over the start point, provided that he notes the divergence to left or right of his intended track line, and allows for it in checking his position at the end of the run. The essential fact is that the calculated compass course should be maintained.

Note.—The angular difference between the magnetic bearing of the track line and the final magnetic course to be steered by the pilot will represent the number of degrees, port or starboard, which the camera must be turned on the turntable, in order to obtain photographs in the correct fore-and-aft line (*i.e.*, without showing " crab ").

(iii) *When no Maps, or inadequate Maps only, are available.—On the Ground.*—No preparations can be made on the ground under these circumstances beyond obtaining such information as is available as to the whereabouts of the track required.

(iv) *When no Maps, or inadequate Maps only, are Available.—In the Air.*—

(*a*) Proceed to the locality concerned and identify the track required.

(*b*) Estimate the magnetic bearing of the required track line. When no special instruments are available for the purpose, the bearing can be estimated either by flying the aircraft with its longitudinal axis pointing along the track line, ignoring the drift over the ground, or by passing vertically over one extremity of the track line, with the aircraft pointing along the track, and noting the compass course.

(*c*) Return to the starting point, adjust the aircraft to fly " hands off " at cruising speed, and by trial and error determine the compass course to be flown in order to make good the desired track line.

Note.—The angular difference between the magnetic bearing of the track line and the final magnetic course to be steered by the pilot will represent the number of degrees, port or starboard, which the camera must be turned on the turntable in order to obtain photographs in the correct fore-and-aft line (*i.e.*, without showing " crab ").

16. *Pilot and Camera Operator* (where the camera operator assists the pilot with the air navigation and also operates the camera) :—

(i) *When Maps are available.—On the Ground.*—The appropriate procedure will be the same as that laid down in para. 15 (i). The camera operator will assist the pilot with calculations.

(ii) *When Maps are available.—In the Air.*—The procedure will be the same as that laid down in para. 15 (ii), except (sub-paras. (*d*) and (*e*)) that the camera operator will check the tracks made good, and pass any necessary corrections to the pilot. The pilot will thus be left free to concentrate on flying the aircraft straight and level. If a course setting bomb sight is available and can be used, then the drift reading necessary to make good the required track will be taken, and from this the correct compass course to be flown will be calculated.

(iii) *When no Maps, or Inadequate Maps only, are available.*—The procedure will be the same as that laid down in para. 15 (iii) and (iv), except that the camera operator will check the tracks made good, and pass any necessary corrections to the pilot. If a course setting bomb sight is available and can be used, then the drift reading necessary to make good the required track will be taken, and from this the correct compass course to be flown will be calculated.

Line Overlaps

17. Line overlaps are divided into two types :—

(i) Cross-country line overlaps, which consist of a single straight line of overlapping photographs along a given track.

(ii) Feature line overlaps, which are produced by following such features as railways, rivers, roads, etc., the object being to keep the feature in the centre of the line of the overlapping photographs.

18. *Cross-country Line Overlaps undertaken by Pilot and Air Gunner* (where the air gunner takes no part in the air navigation or the operation of the camera, as in army co-operation squadrons).

(i) *On the Ground.*—The procedure to be followed will be the same as that laid down for pin-points, vertical photography, para. 4, except that the pilot will in addition :—

(*a*) Ascertain the locality of the required overlap, and if maps are available proceed as laid down in para. 15, " To make good a given track ".

(*b*) Determine the number of exposures and the correct time interval for the fore-and-aft overlap in the manner described in paras. 8 and 9.

(ii) *In the Air : Duties of Pilot.*—

(*a*) Carry out the appropriate procedure recommended in para. 15, at the pre-arranged photographic height, and check the time interval.

(*b*) Instruct the air gunner to turn the camera the required number of degrees port or starboard.

(*c*) Fly straight and level with the aircraft trimmed, and instruct the air gunner to level camera.

(*d*) Carry out the appropriate procedure for approaching the start point (para. 5).

(*e*) Continue to make exposures with the determined time intervals until the run is completed.

(iii) *In the Air : Duties of Air Gunner.*—

(*a*) On receiving the instructions from the pilot, set the camera in the turntable with drift as ordered.

(*b*) When the pilot indicates that the aircraft is flying level at the correct height, level the camera.

(*c*) Periodically check that the camera is operating correctly. In the case of the P.7 (hand-operated) camera change the plates.

19. *Cross-country Line Overlaps undertaken by Pilot and Camera Operator* (where the camera operator assists the pilot with the air navigation and also operates the camera).

(i) *On the Ground.*—The procedure to be followed will be that laid down in para. 18 (i) above, except that all calculations, etc., will be determined by camera operator and pilot working in conjunction.

(ii) *In the Air : Duties of Pilot.*—

(*a*) Carry out the procedure laid down in para. 16 in order to find the correct compass course to steer to make good a given track.

(*b*) Fly straight and level with the aircraft trimmed, and instruct the camera operator to level the camera.

(*c*) Carry out the appropriate procedure for approaching the start point (para. 5) and fly straight and level on the calculated compass course until the camera operator indicates that the run is finished.

(iii) *In the Air : Duties of Camera Operator.*

(*a*) Co-operate with the pilot by assisting to determine the correct compass course to make good a given track, as laid down in para. 16.

(*b*) Check the time interval for the fore-and-aft overlap, and if electrical control is to be used, set this time interval thereon.

(*c*) Set the camera with the appropriate number of degrees of port or starboard drift.

(*d*) Ask the pilot to fly straight and level. Level the camera.

(*e*) Assist the pilot to approach the start point (para. 5).

(*f*) Commence photography when the aircraft passes over the start point, and continue to make exposures with appropriate time intervals during the run.

(*g*) During the run, check the drift by means of the sight (if available) and by reference to the ground and map (if available).

(*h*) Check camera and level during run.

(*j*) Inform pilot when run is finished.

20. *Feature Line Overlaps.*—There are two methods of undertaking these overlaps :—

(i) Follow the feature by means of flat turns, where necessary, care being taken to have the aircraft level at the time of exposure.

(ii) If the feature does not allow flat turns to be made successfully, the run should be broken off and recommenced in the new direction, taking care that the overlap is maintained where the break occurred.

The broad principles laid down for cross-country line overlaps should be followed, but the fore-and-aft time interval and the drift reading should be determined for the general direction of the feature only. It should be noted that the time interval will have to be shortened considerably when a flat turn is made in order to ensure that no gap occurs between consecutive exposures.

PHOTOGRAPHIC STEREO PAIRS—USE OF THE MARK VIIA AND MARK IXA C.S.B.S. FOR SIGHTING.—See also A.P. 1355/A.32

20A. In order to utilise the above-mentioned bombsights to obtain photographs of a ground object with a 60 per cent. overlap for use in a stereoscope, it is necessary to make adjustments to the height bar to enable the sighting lines to be obtained. The following procedure should be adopted :—

(i) *Before leaving the ground.*—(*a*) Tie a piece of thin white string or twine firmly round one of the drift wires—say, the right hand outer one—between the two beads nearest the inner end of the drift wire. By means of a small square, adjust this band of string to be level with a given groundspeed mark as determined from Table I. Note the corresponding height setting in Table I for the red timing scale.

(ii) *When in the air* (*at operational height*).—(*a*) Level the bombsight and set T.V. = o0.

(*b*) Compute true height and airspeed and set these on the sight.

(*c*) Find W.S. and D. by any method and set on the sight.

(*d*) Set 30 knots enemy speed in the direction of motion of the aircraft.

(*e*) Add 35 m.p.h. to the true airspeed found in (ii) (*b*) and alter the airspeed setting accordingly.

(*f*) Set the height noted in (i) (*a*) on the red timing scale.

(iii) The aircraft should now be manoeuvred as for ordinary bombing practice, the target being made to move down the drift wires with red set on red.

(iv) The first photograph must be exposed when the line of sight from the backsight point to the string band on the drift wire reaches the target; at the same instant a stop watch should be started.

(v) The second photograph (with a 60 per cent. overlap with the first) should be taken at a given interval in seconds after the first exposure. This time interval can be obtained either

(*a*) by noting ground-speed during the run-up on to the target, obtaining the time interval from Table II and exposing when this time is reached on the stop watch; or

(*b*) by using a stop watch with a check hand. This hand can be checked when the aircraft is vertically above the target and the time indicated by the hand doubled. The second photograph should then be exposed when this double time is reached on the stop watch.

N.B.—Method (*b*) may be impracticable in some aircraft owing to the floor structure precluding any possibility of seeing vertically.

TABLE I

		5-in. lens	8-in. lens	14-in. lens	20-in. lens
Mark VIIA.	Height, feet ..	7,600	12,170	6,200	8,950
	Groundspeed setting	60 m.p.h.	60 m.p.h	30 m.p.h.	30 m.p.h.
Mark IXA.	Height, feet ..	6,860	11,000	11,240	14,320
	Groundspeed setting	70 m.p.h.	70 m.p.h.	50 m.p.h.	50 m.p.h. less ·06 in.

To obtain time interval in seconds, divide factor in table by focal length of camera lens.

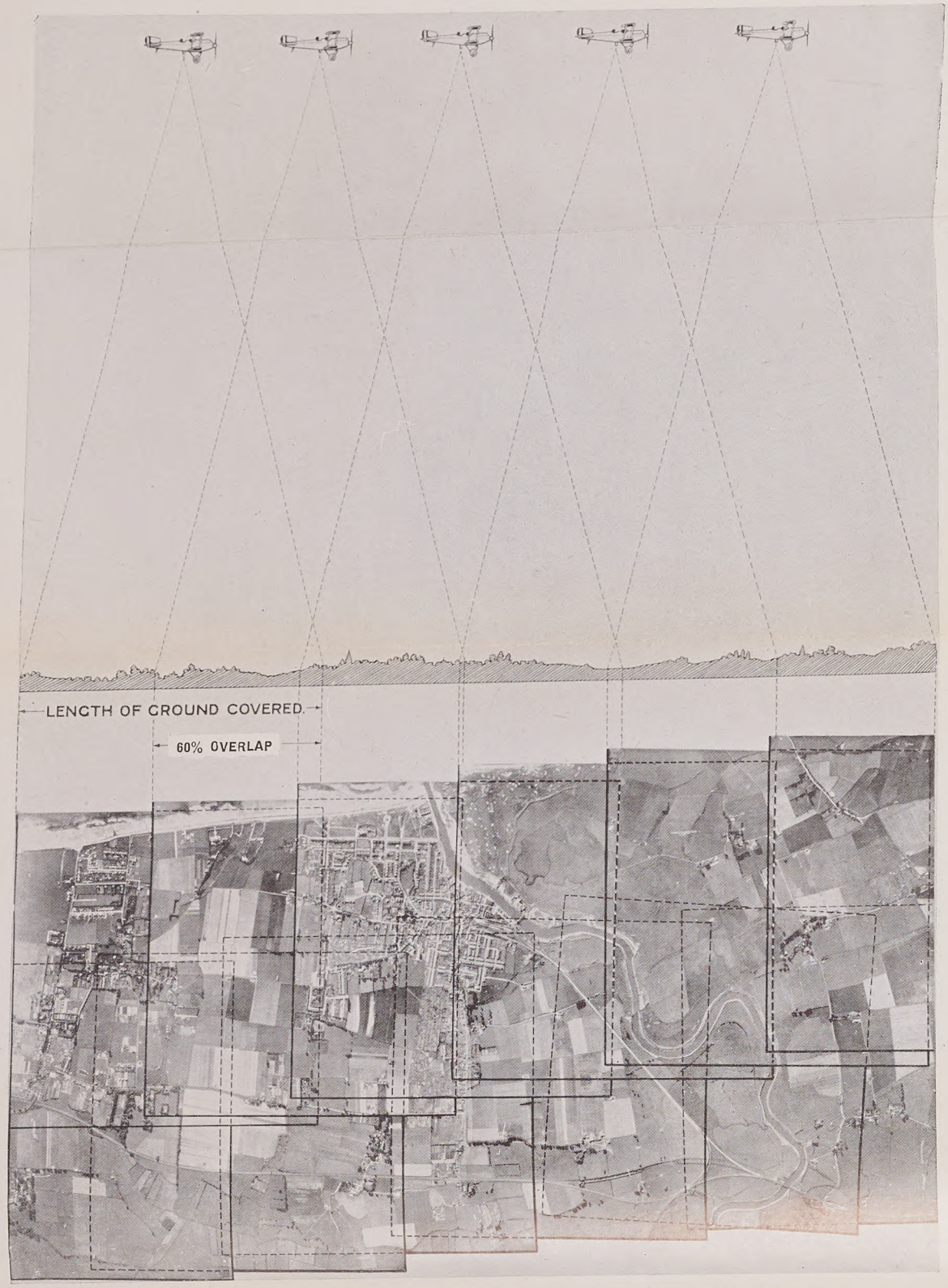
Note.—Figures to the left of and below the thick lines give time intervals of less than 3 secs. for the appropriate focal length. They may be disregarded.

TABLE II

TRUE HEIGHT OF AIRCRAFT IN FEET

Ground Speed in M.P.H.	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000
100 ..	27	41	54	68	82	95	109	122	136	150	163	177	190	204	218	231	245	258	272
120 ..	23	34	45	57	68	79	91	102	113	125	136	147	159	170	181	193	204	216	226
140 ..	19	29	39	49	58	68	78	88	97	107	117	126	136	146	156	165	175	185	194
160 ..	17	25	34	42	51	59	68	76	85	93	102	110	119	128	136	145	153	162	170
180 ..	15	23	30	38	45	53	60	68	75	83	91	98	106	113	121	128	136	144	151
200 ..	14	20	27	34	41	48	54	61	68	75	82	88	95	102	109	116	122	129	136
220 ..	12	18	25	31	37	43	49	56	62	68	74	80	87	93	99	105	111	117	124
240 ..	11	17	23	28	34	40	45	51	57	62	68	74	79	85	91	96	102	108	113
260 ..	10	16	21	26	31	37	42	47	52	57	63	68	73	78	84	89	94	99	105
280 ..	10	15	19	24	29	34	39	44	49	53	58	63	68	73	78	83	87	92	97
300 ..	9	14	18	23	27	32	36	41	45	50	54	59	63	68	73	77	82	86	91
		5 in.		8 in.				14 in.				20 in.							

[*To face para.* 22.



CHAPTER IV, FIG. 2.—Example of 60 per cent. fore-and-aft overlap, 30 per cent. lateral overlap.

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MOSAICS

21. (i) A mosaic, in its simple form, consists of a series of parallel cross-country line overlaps, overlapping each other laterally.

(ii) When no maps, or inadequate maps only, are available, it will be found necessary to fly one or more strips of photographs across the mean direction of the run lines to assist the crew of the aircraft in determining any navigational errors made and to keep a check on distortional errors in compilation, if a type 2 mosaic (*see* Chapter V) is required.

(iii) The general direction of the run lines will be governed partly by considerations of the shape of the area and the direction of the wind, but the main guiding principle is that strips will not be arranged to run in a northerly or southerly direction unless unavoidable, owing to northerly turning error and the sun.

22. *Lateral Overlap.*—The lateral overlap is determined by the distance between parallel runs. The percentage of lateral overlap to be aimed at is to some extent dependent upon the experience of the crew of the aircraft, but as a general rule 30 per cent. may be taken as a good average and is therefore the standard lateral overlap in the Royal Air Force. A simple 60 per cent. fore-and-aft overlap with a lateral overlap of 30 per cent. is illustrated in fig. 2.

Flying for Mosaics, including Methods to obtain and maintain the Lateral Overlap.

23. *If Maps are available.*—(i) *On the Ground.*—The procedure will be the same as that laid down in para. 18 (i) or 19 (i), according to the type of unit. In addition, work out, by means of the appropriate formula, the distance between each run for the lateral overlap desired. Decide upon the direction and length of the run lines and then select suitable points for start points at the proper distance apart on the map, which may be identified easily from the air. Unless considerable experience has been gained in this type of work it will be advisable to arrange to fly all the runs upon the same course and not to attempt to do alternate parallel runs upon reciprocal courses. The latter method may be practised as an advanced form of training.

(ii) *In the Air.*—The procedure will be the same as laid down in para. 18 (ii) and (iii), or 19 (ii) and (iii), according to the type of unit, with one of the following variations to ensure covering the photographic area concerned.

(*a*) Commence each run over one of the determined start points and fly the aircraft on a parallel course each time, in the proper direction. The lateral overlap

of the resultant strips will then be correct, provided that the standard of flying has been good and that the strips are not of excessive length. No attempt will be made to correct the course during the actual runs. The length of the runs will be decided by the number of exposures calculated.

(*b*) This alternative method is only to be attempted when the camera operator is available to assist the pilot. Commence each run over one of the determined start points and fly the aircraft on the pre-arranged compass course down the track line marked on the map. The camera operator checks the position of the aircraft at frequent intervals by reference to the maps and gives the pilot suitable corrections "left" or "right", if necessary. This method has an advantage in that the run will be known to finish over the correct finishing point but it calls for a very high standard of map reading on the part of the camera operator, combined with instant notification of the corrections to the pilot. The pilot will have to exercise considerable skill in making the necessary corrections and also be in very close co-operation with the camera operator. This method should only be attempted during advanced training.

24. *If no Maps, or inadequate Maps only are available.*— (i) Obtain all the information possible from ground sources, and supplement, if necessary, by air reconnaissance. Decide upon the direction and length of the run lines. It will now be necessary to fix upon the actual start points. In order to do this a strip of photographs must be obtained across the run lines on that side of the area from which it is proposed to commence the runs. This strip should be obtained in the manner laid down in para. 18 or 19, as appropriate. Mark on the photographs the actual start points, having regard to the height, focal length of the lens, size of the negative and percentage of overlap required, and mark also the approximate tracks to be made good. Copies of these photographs can now be used by the crew of the aircraft to take into the air to enable them to undertake the photography in the same manner as laid down in para. 23 (ii) (*a*). It may be advisable, in order to correct distortional errors in mounting a type 2 mosaic, to obtain a second strip of photographs across the run lines in the vicinity of the finishing points. This will facilitate the work of the ground personnel in laying down the prints.

(ii) If the area to be photographed contains long runs (e.g., about 10 miles), the procedure outlined above should

be followed, with the exception that the second strip of photographs across the run lines, in the vicinity of the finishing points, should be flown before the main run lines are commenced. The prints of this " finishing " strip should be taken into the air without any theoretical finishing points marked, as these will, of course, be unknown, and should be used by the crew to put in each actual finishing point of a run as it is completed. It will now be possible to ensure in the air at the conclusion of each run, by noting the relative position of the finishing points which have been marked, that the correct lateral overlap as been maintained.

(iii) If the area to be photographed is a large one, necessitating a division into sectors for photograph purposes, then the problem will be solved best by the application of air survey methods of flying. The details of procedure in this case can be obtained by reference to Part II of this chapter.

OBLIQUE PHOTOGRAPHY

25. Oblique photographs may be taken with a hand-held camera or by means of a camera fitted in a standard mounting in the aircraft and inclined at a fixed angle from the horizontal. The most suitable height and distance of the aircraft relative to the objective cannot be laid down definitely owing to the varying types of obliques which may be required.

Pin-points, Hand-held Oblique Photography

26. *On the Ground.*—(i) *Duties of the Photographic Section.*

(*a*) Load the film

or

Load the plates, and place them in a suitable box for comfortable and safe stowage.

(*b*) Set the counter to zero.

(*c*) Set the exposure on the camera.

(*d*) In the case of film camera. Fit the magazine, and provide electric lead for recording instrument.

(*e*) Test the camera in the presence of the camera operator, and advise as to exposure set.

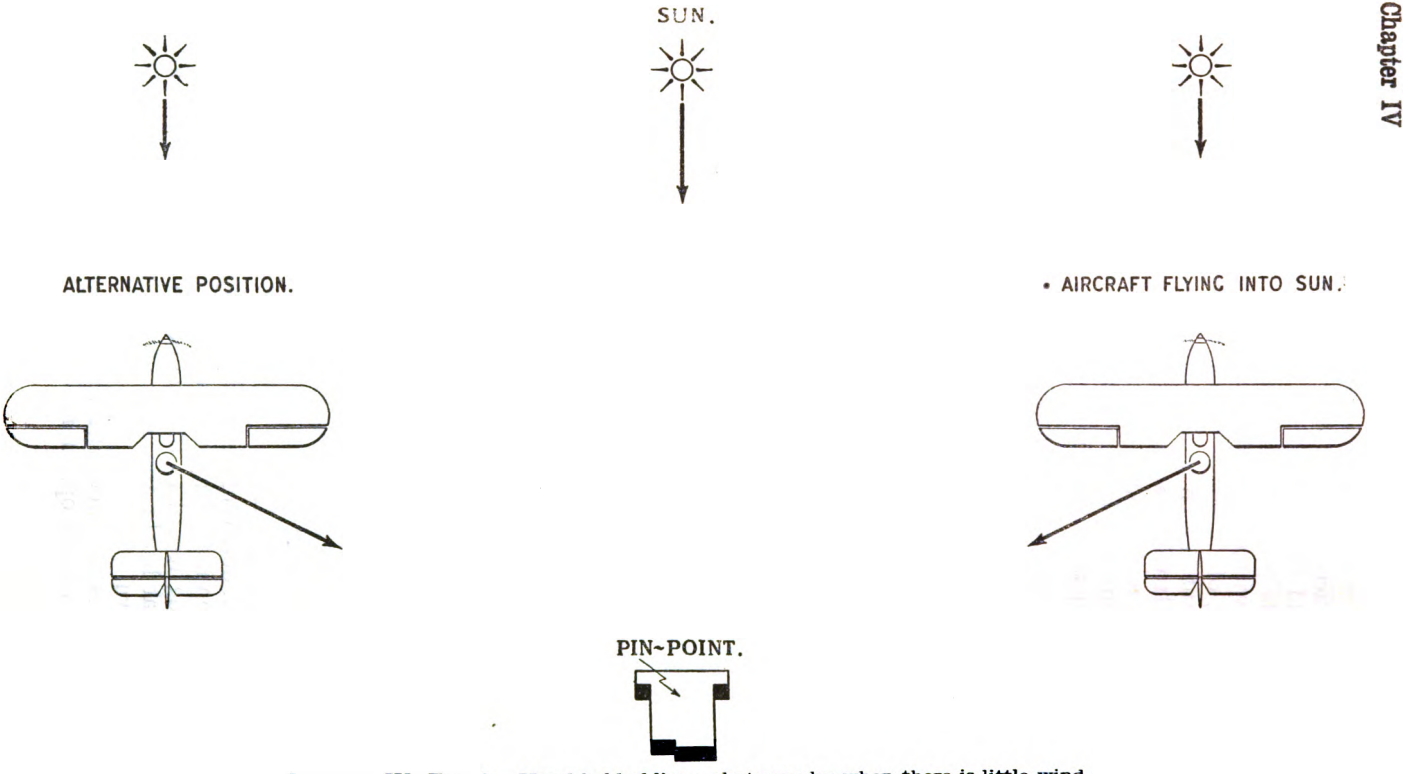
(*f*) Hand over.

(ii) *Duties of Pilot.*—

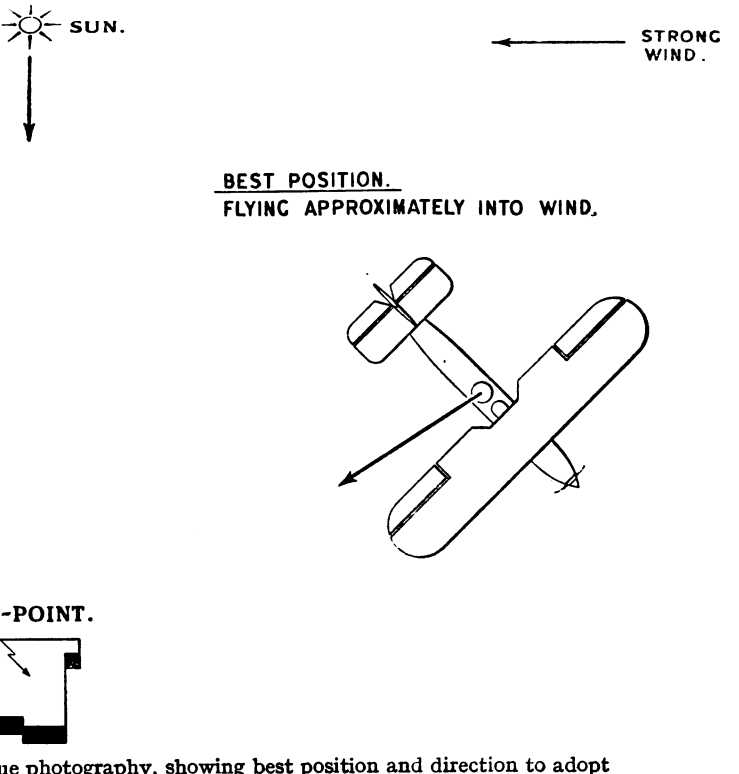
(*a*) Obtain details of photographic requirements and mark upon map, if appropriate.

(*b*) Having regard to the size of the objective decide at what height above the ground the aircraft is to be flown.

(*c*) Discuss the procedure to be adopted in the air with the camera operator.



CHAPTER IV, FIG. 3.—Hand-held oblique photography when there is little wind.



CHAPTER IV, FIG. 4.—Hand-held oblique photography, showing best position and direction to adopt when strong wind is blowing.

(iii) *Duties of Camera Operator.*—

(*a*) Obtain details of photographic requirements and discuss procedure to be adopted in the air with the pilot.

(*b*) See camera tested by the photographic personnel, check exposure set, take over the photographic equipment and stow in aircraft.

27. *In the Air.*—(i) Pilot and camera operator identify the pin-point, and decide upon the position from which the photograph will be taken. In reaching this decision the following factors should be borne in mind and adhered to as closely as possible :—

(*a*) Camera pointing midway between " down-sun " and " cross-sun." This will cause buildings, etc., to show up in " relief."

(*b*) Time of day which will give the most suitable view, having regard to (*a*) above.

(*c*) Aircraft flying as nearly into wind as is practicable.

(*d*) Camera pointing so that no portion of the structure of the aircraft will be visible in the photograph. (This position in a tractor biplane will be between the trailing edge of the main planes and the leading edge of the tail plane.) (*See* figs. 3 and 4.)

Note.—When maps are available, it will usually be possible to decide, before leaving the ground, what bearing these factors will have on the decision.

(ii) Normally before exposure, the engine(s) should be throttled right down and the aircraft put into as slow a glide as is compatible with safety. It is desirable to throttle the engine(s) down in order to minimise vibration. It is particularly important that the aircraft should be flying as slowly as possible in the case of low flying obliques. Otherwise " movement " will be apparent in the resultant photographs. It cannot be too strongly emphasised that good, sharp photographic results are almost entirely dependent upon the firmness with which the camera is held, it should be gripped firmly with both hands and pulled well into the body for sighting. The arms should not touch any portion of the aircraft, and the body should be braced to give the most efficient support possible. The exposure should be made by exerting a steady pressure upon the trigger release, in the same way as in firing a rifle. Any tendency to " snatch " at the moment of exposure invariably causes unsharp and indefinite results. All possible means to prevent vibration should be taken. The camera operator, by means of a pre-arranged signal, should inform the pilot as soon as exposure has been made, to enable the latter to open his throttle and carry on with as little delay as possible.

Pin-points, Fixed Oblique Photography

28. The exposure in this case may be made either by the pilot or by the camera operator. In either case the camera (film type) will be placed in the mounting at a known angle of inclination to the horizontal, and, when possible, at right-angles to the fore-and-aft line of the aircraft.

29. *Sighting arrangements.*—It is not considered either necessary or desirable to have a special sight for fixed oblique photographs. Units in which this type of photography is to be practised, should arrange marks on some portion of the aircraft in such a way that a line of sight from the eye of the pilot or camera operator through, or alongside, the mark to the ground will indicate the approximate centre of the photograph. In the average tractor biplane this mark can be fixed as follows :—

Decide at what angle of inclination from the horizontal the camera is to be used, having regard to the type of lens, and to the normal requirements. Set up the aircraft in flying position, and measure off the same angle of inclination from the position of the eye of the pilot or camera operator, and at right-angles to the fore-and-aft line of the fuselage. This line will pass near the trailing edge of the port lower main plane. A mark can now be made at the nearest point on the wing.

It will be realised that this method is approximate only, but a very small amount of practice will enable the pilot or camera operator concerned to determine how much to " aim off " in order to obtain accurate results.

30. *On the Ground.*—(i) *Duties of the Photographic Section.*—

(*a*) Load the film.

(*b*) Fit the camera in mounting in aircraft, magazine in position.

(*c*) Set exposure on camera.

(*d*) Set the counter to zero.

(*e*) Adjust camera to correct angle of inclination, and in neutral position on the drift scale.

(*f*) Test camera in presence of camera operator, and advise as to exposure set.

(*g*) Inform pilot (or camera operator) of the angle of inclination set to enable him to use the correct wing mark for sighting.

(*h*) Hang over.

(ii) *Duties of Pilot.*—

(*a*) Obtain details of the photographic requirements, and mark up on map if appropriate.

(*b*) Discuss with the camera operator or air gunner the procedure to be adopted in the air.

(*c*) Determine the wing mark to be used for sighting purposes.

(iii) *Duties of Camera Operator or Air Gunner.*—

(*a*) Obtain details of the photographic requirements, and discuss procedure to be adopted in the air with the pilot.

(*b*) See camera tested by photographic personnel, and check exposure set.

(*c*) Take over photographic equipment.

31. *In the Air.*—(i) After leaving the ground, and before approaching the objective, two trial exposures should be made to ensure that the camera is working correctly.

(ii) Pilot and camera operator identify the pin-point and decide upon the position from which the photograph will be taken. In reaching this decision the considerations will be the same as those discussed in para. 27 (i) above.

(iii) The pilot will now handle the aircraft in such a way as to bring it into the position chosen, with the wing marks in line with the pin-point at the moment of exposure. The aircraft must be flying level at normal cruising speed and in the direction chosen.

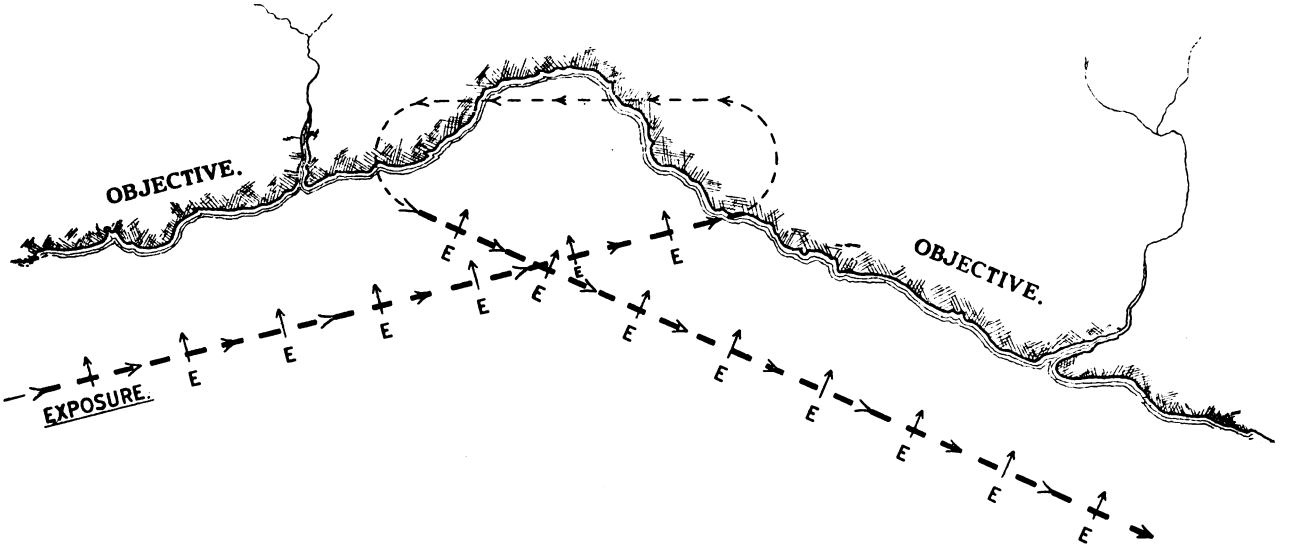
Overlaps, Fixed Oblique Photography

32. *On the Ground.*—(i) The procedure on the ground for the photographic section and crew of the aircraft will be the same as that laid down for pin-points, fixed oblique photography, para. 30.

(ii) When maps are available the data given in Appendix V should be used to calculate the time interval and to mark the track line over which the aircraft must be flown in order to maintain the line of objectives approximately in the middle distance, or foreground, as required.

(iii) Appendix V contains a set of tables showing the length of foreground covered by one exposure with an F.24 camera fitted with six inch or eight inch lenses, at angles of inclination from the horizontal between 15 and 30 degrees and for various heights above the ground. The horizontal distances between the aircraft and the foreground and the aircraft and the middle distance of the photograph are also given.

(iv) If the length of foreground (in feet) covered by one exposure is divided by the estimated ground speed of the aircraft (in feet per second) the answer will be (in seconds)



CHAPTER IV, FIG. 5.—Overlaps, fixed oblique photography.

the time interval necessary to enable exposures to be made so that the detail is continuous in the foreground of consecutive photographs.

(v) It will be realised that the above information can only be used with accuracy when flying over approximately flat country, and when the camera is set at right angles to the fore-and-aft line of the aircraft. It may be necessary to "off-set" the camera from this line, when the lenses are of the wide angle type, or in order to avoid some portion of the structure of the aircraft. The effective angle of view in the F.24 camera

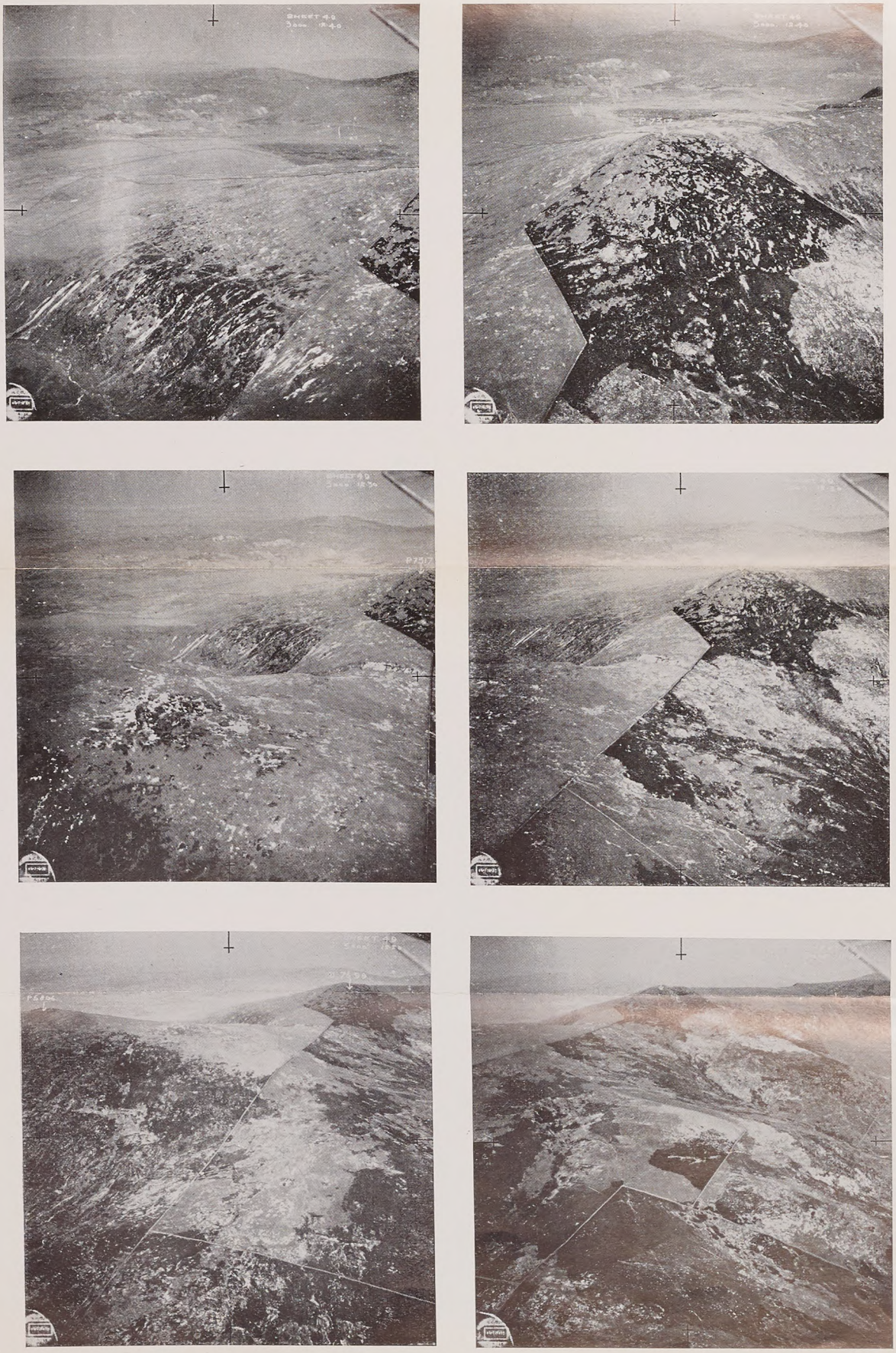
for a 5 inch lens	..	..	..	52°
for a 6 inch lens	..	..	..	45°
for an 8 inch lens	..	..	..	35°

33. *In the Air.*—(i) If the aircraft is flown straight and level down a pre-arranged track, as calculated from the tables given in Appendix V, the line of objectives will then appear approximately in the middle distance of the photographs. If the line of objectives deviates considerably from its original direction, photography should be stopped. The exposures should be resumed with the aircraft flying on such a new course, but at the same height, so that the line of objectives will still appear in the middle distance of the photographs (*see* fig. 5). Care must be taken to ensure that the two lines overlap where the break occurred. If this method is employed, then the procedure to be followed will be the same in principle as that laid down for line overlaps, vertical photography (*see* paras. 18–19).

(ii) In many cases it will be found sufficient to use the wing mark, referred to in para. 29, as a guide for flying down the line of objectives, but when this method is adopted care must be taken that the aircraft is level at the moment of exposure, and also that, if the aircraft is turned at all, there is no gap between consecutive photographs.

Oblique Mosaic

34. Oblique photographs may be taken so that they overlap not only laterally but also in depth, *i.e.*, so that the detail appearing in the middle distance of one run of overlapping obliques (*see* paras. 32–33) will be seen in the foreground of a second run flown on a parallel course and in the appropriate position. A series of such runs will constitute an oblique mosaic (*see* fig. 6). This type of photography is of particular use when co-operating with mobile troops. The detailed method of procedure will be apparent from a perusal of aras. 28–33.



CHAPTER IV, FIG. 6.—Example of oblique mosaic.

[To face para. 34.

(50253)

AIR SURVEY

Introduction

35. Accurate maps are essential for the proper conduct of military and air operations, and for administrative purposes in time of peace. It is the duty of the Geographical Section of the General Staff to ensure the supply of such maps to the Army and Royal Air Force, and, where possible, maps of the most important areas are prepared in advance. In some cases, however, the local surveys are not sufficiently accurate for purposes of modern warfare, and a new survey has to be carried out. Air photography opens up the possibility of mapping areas which have never been visited on the ground, and for this purpose a suitable technique has been developed. Photography must be carried out in a certain definite way which makes considerable demands upon the skill of the pilot and photographer, and failure to achieve this standard will greatly diminish the value of the photographs to the surveyor. When an air survey is undertaken, the Royal Air Force will provide the photographs and Field Survey Companies of the Royal Engineers will carry out the necessary survey work. The method therefore divides itself into two parts :—

(i) The cartographic problem (Royal Engineers).

(ii) The photographic problem (Royal Air Force), and no true application of the one can be obtained without an accurate and sympathetic understanding of the other. In paras. 36–45 which follow, therefore, is given a brief introduction to the problems of the surveyor in order to provide sufficient background for the proper study of the air problem in subsequent paragraphs.

THE CARTOGRAPHIC PROBLEM

Types of Photographs

36. Oblique photographs may be used for survey purposes where the country is practically flat and where the detail to be depicted is very clearly defined. (*cf.* Canadian conditions, where the detail consists of the boundaries between woods and lakes, and the height of the country does not rise above 200 feet.) They are not, however, suitable for ordinary conditions where there is considerable variation in height and/or the detail is of a finer and less easily interpreted nature.

37. Vertical photographs are suitable for any type of country and can be made the basis of a standard method of plotting which is described below.

Chapter IV

Method of Plotting from Vertical Photographs

38. If an absolutely vertical photograph is taken of flat country the result will be a plan of the ground to some definite scale. In practice, however, it is impossible to take photographs without tilt, and if tilt is present distortions are introduced which make a photograph no longer a true plan. Furthermore, ordinary country is not absolutely flat, and variations of ground height cause further distortions on the photograph. Every contour on the ground is, in fact, photographed at a different scale. Owing to these two forms of distortion no method of plotting based on simple tracing from the photograph can be used.

39. The pressure plate of a camera carries on it collimating marks which appear on the photographs. The intersection of the lines joining opposite collimating marks is known as the plate centre. The foot of the perpendicular from the perspective centre of the lens (rear nodal point) is known as the principal point. In a properly adjusted camera these two points should coincide, but in practice there is always a slight discrepancy. The position of the principal point relative to the plate centre is found by means of calibration and is recorded for each survey camera. Calibration is also used to determine the principal distance or true focal length.

40. Now, provided the tilt on a photograph is kept small, the two forms of distortion mentioned above may be considered as taking place radially from the principal point. That is to say, angles subtended at the principal point by points of detail on the photograph are accepted as true. This assumption will lead to a simple method of plotting which is sufficiently accurate for mapping purposes, provided the tilt is not greater than about 2° and the variation in height of the ground of any given photograph is not greater than 10 per cent. of the altitude of the aircraft.

41. The radial assumption enables a method of graphical triangulation to be used, by means of which the points of detail on the photographs may be plotted in their correct relative positions on to celluloid strips. For this purpose the photographs should be taken in strips, having a fore-and-aft overlap of 60 per cent. between each successive pair of photographs (in order to obtain a small area common to every *three* successive photographs), and a lateral overlap of 30 per cent. with neighbouring strips. The detail on the celluloid plots is brought to the required scale photographically, or otherwise, and, finally, fair drawings embodying the conventional signs, are made for reproduction in map form.

42. A fore-and-aft overlap of 60 per cent. will ensure that every point on the ground is photographed from two positions

in the air. The ground covered by the overlap of any pair of photographs may, therefore, be viewed stereoscopically in the same way that binocular vision enables us to appreciate the solid in ordinary life. The topography is seen as a small scale relief model which enables contouring to be carried out. For this purpose it is most desirable that the photographs should be taken *in the same horizontal plane.* This entails flying at a constant height and without tilt.

43. " *Ground Control.*"—The accuracy of a map constructed in the way described above is maintained by fixing the relative positions of a few points scattered throughout the area by means of well-known ground methods. This ground survey is called " Ground Control ". The greater the degree of " ground control " provided the more accurate the map. In time of war it is not possible, of course, for the surveyor to visit points in enemy territory. The air photography, however, will start from " fixed " points in known territory and the resultant map will depend for its accuracy on the radial plotting method, and the stereoscopic examination of the air photographs.

44. For further information on the survey problem reference should be made to Professional Paper No. 8 of the Air Survey Committee, a copy of which should be in the possession of any R.A.F. personnel engaged upon air survey work.

Surveyor's Requirements

45. The photographic requirements of the surveyor may now be tabulated. It will be appreciated that these requirements, though severe, would arise in any case if the primary object was merely to cover the ground photographically in the most economical manner.

(i) Flying should be carried out at as high an altitude as possible for the following reasons :—

(*a*) In order to cover the greatest amount of ground on a single photograph.

(*b*) To ensure that the variation in height of the ground is not greater than 10 per cent. of the altitude of the aircraft.

(*c*) To minimise the risk of interruption by H.A. or A.A. fire.

(*d*) To cut down the number of " runs " to the minimum.

(*e*) To give the least amount of work to the survey party.

When using either the F.8 camera or the F.24 camera in conjunction with a permanent enlarger a suitable height has been found to be 15,000 ft. above ground level.

(ii) Strip flights should be made at a constant height. Variation in height produces an effect in a stereoscope equivalent to tilt.

(iii) The fore-and-aft overlap between pairs of photographs should be 60 per cent. The method breaks down if the overlap falls below 50 per cent., and an adequate, though not excessive, margin is necessary.

(iv) The lateral overlap between strips will depend on the skill in navigation and the length of the strips, but should not be less than 25 per cent.

(v) From a consideration of the factors given in (i) (*a*), (*d*) and (*e*) above, the lens used in the camera should be of the shortest available focal length; *e.g.* for the F.8 camera 7 inch lens, for the F.24 camera 5 inch lens.

THE PHOTOGRAPHIC PROBLEM

General

46. It will be obvious from a perusal of earlier paragraphs, "The Cartographic Problem," and a study of the requirements laid down in para. 45, that the problem from the R.A.F. point of view is mainly one of accurate navigation. The surveyor's requirements call for uninterrupted photographic "runs" of considerable length. These may well be extremely difficult to obtain under war conditions. Success in obtaining them will be dependent upon our having or securing a sufficiently favourable air situation and it is important, in order that full advantage may be taken of all opportunities with the minimum loss of time, to ensure that the crew of the aircraft have reached a high standard of training.

47. A satisfactory air camera for survey purposes has been evolved in the Service F.8 type, and later developments, of which full particulars will be found in the appropriate air publications. This aspect of the problem may, therefore, be omitted in this publication, except in the consideration of minor points in regard to fitting, etc.

48. It must be emphasised that the closest co-operation with the R.E. Survey Party throughout the survey is essential. A conference with them should be arranged as soon as information of the requirements is received, and from that time constant liaison must be maintained.

Consideration of the R.A.F. Aircraft and Equipment Suitable and Available

49. Before discussing in detail the procedure which has been developed, it is necessary to consider the type of aircraft required, navigation instruments available, etc.

50. *Aircraft.*—Any service aeroplane which is constructed to carry a pilot and observer, which is stable and can be

flown " hands off," can be adapted for the purpose, provided that there is sufficient room to fit the instruments detailed below. An aeroplane fitted with the automatic pilot will, of course, greatly simplify the work of the pilot and observer, and render results more accurate.

51. *Camera.*—The survey camera will be either the F.8 or such other survey instrument as may become available. Care must be taken to ensure that this camera is capable of being fitted satisfactorily in the type of aircraft to be used.

52. *Compass.*—The pilot's compass should be capable of giving readings accurate to 1 degree, free from excessive deviations, and must be fitted in a position where it can be read easily and conveniently.

53. *Aldis Photographic Sight with Prism.*—A brief description of this sight, and the principle upon which it is used is given below in order that the navigation procedure may be understood :—

(i) The sight is of the negative lens type, fitted with a moving prism at the lower end, by means of which the vertical view, obtained when the sight is fitted in an aircraft, can be extended to reach the horizon looking either ahead or astern in the line of flight.

(ii) The sight is mounted in a bracket in such a way that it can be rotated in azimuth, and also levelled both fore-and-aft and laterally to suit the trim of the aeroplane, and correspond with the camera setting.

(iii) A graticule is incorporated in the lens system with marks showing :—
  (*a*) The fore-and-aft line (double).
  (*b*) The centre point of the sight.
  (*c*) Two points to enable the 60 per cent. fore-and-aft time interval to be taken for a given focal length lens and camera.
  (*d*) The area covered by a single exposure for a known focal length lens and camera.

(iv) A scale is fitted to the side of the instrument by means of which the drift, either port or starboard, can be read.

(v) The instrument is used for two purposes :—
  (*a*) To find the drift accurately.
  (*b*) To make good a predetermined track, given navigation prints at known intervals.

(vi) The drift is found by means of tail drift readings. A prominent object is picked up in the vertical field of view, and on the centre line of sight. It is

then followed by means of the prism as it passes astern, the drift being read off on the appropriate scale.

(vii) The instrument is used in case (*b*) to check the course by means of back readings in the prism and then, by reversing the prism and looking ahead, to pick up the known point and guide the pilot over it.

(viii) The detailed procedure in the air for these two operations is given in paras. 73 and 83.

54. *Statoscope.*—A statoscope should be fitted in the pilot's cockpit to enable correct height to be maintained.

Navigation Strip Control in Flying for Air Survey over Unmapped Country

55. The method described in the following paragraphs has been evolved to meet the requirements which have been stated above, having regard to the aircraft and equipment available. It is assumed that the survey is to be made of an indefinitely large area. Modifications in procedure can be made quite simply if this is not so. It is also assumed that no maps whatever are available. If maps of any description are in existence full use of them should, of course, be made.

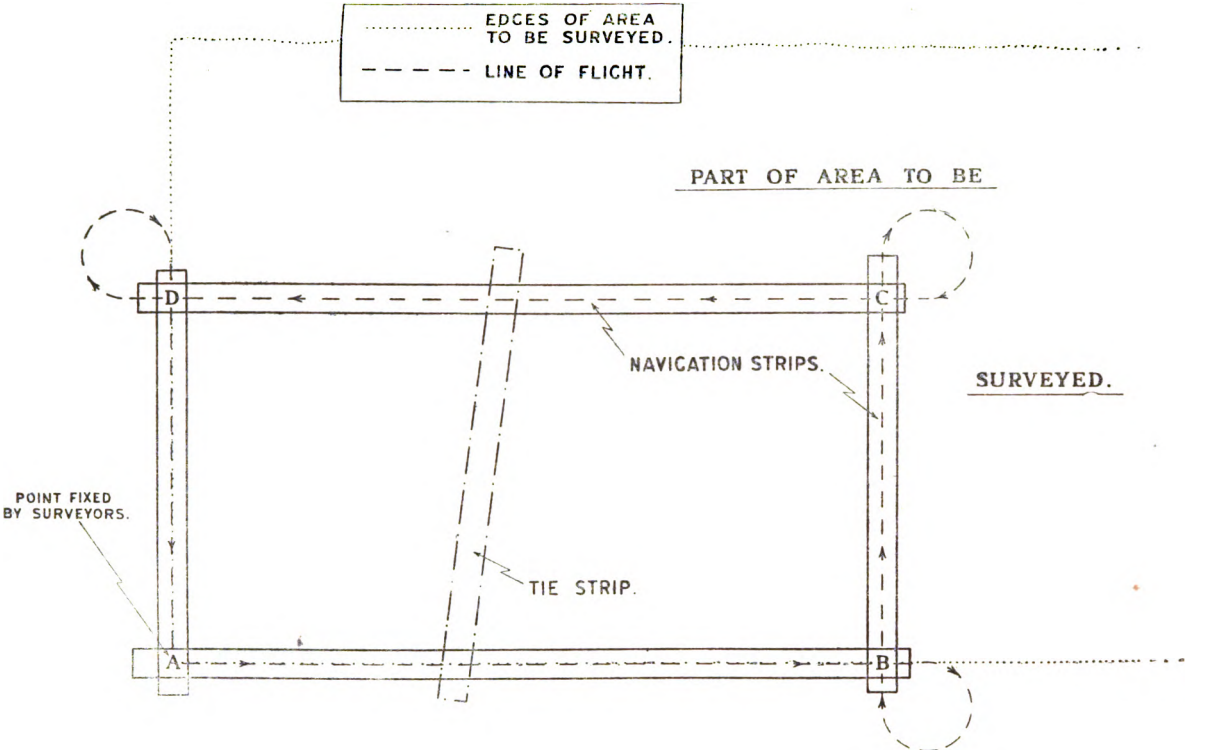
56. (i) Starting from a point fixed by ground control in consultation with the R.E. Survey Party, and running out into the unsurveyed area, a rectangular photographic flight is made, consisting of four courses, known as " navigation " strips, the end photographs of which overlap (*see* fig. 7). This rectangle is then sub-divided by a " tie " strip, or " tie " strips (according to the length of the rectangle).

(ii) The whole of this strip flying has to be done with navigation control. The photographs are given to the R.E. Survey Party, who produce from them a skeleton base map, using the radial plotting method for the purpose.

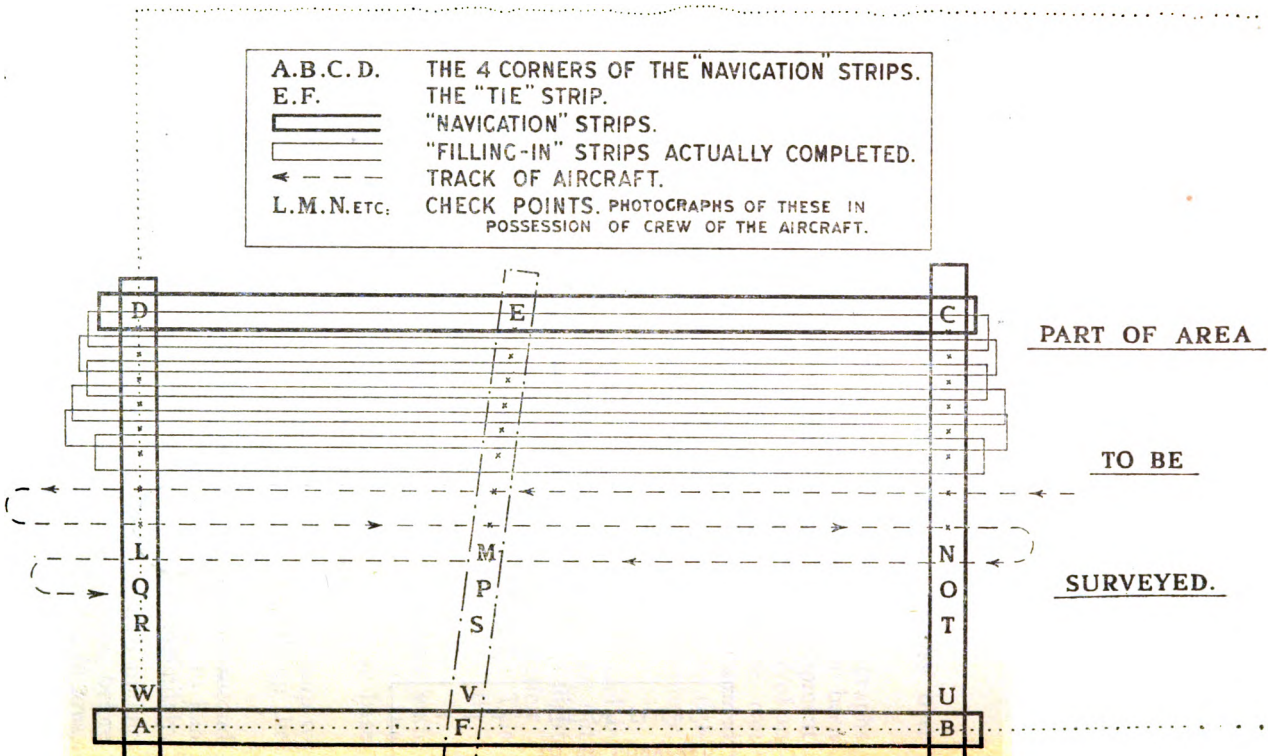
(iii) The crew of the aircraft then use the skeleton map to control the " filling-in " strip flying necessary to fill up the gaps between the intersecting strips (*see* fig. 8).

(iv) On completion of the first rectangular area, a second set of " navigation " and " tie " strips can be flown to join on to the finished section, and the process repeated indefinitely.

57. The principle of obtaining a set of photographs bounding a rectangle, and cross tied at one or more points, before commencing the systematic photography of the whole area, has been adopted for two reasons. Firstly, it provides a satisfactory substitute for maps for the crew to use in the air for the majority of the flying. Secondly, it provides a set of



CHAPTER IV, FIG. 7.—"Navigation" and "Tie" Strips.



CHAPTER IV, FIG. 8.—"Filling-in" strips.

cross strips for the R.E. Survey Party, which enables them to check the other photographic "runs", and position them accurately.

Note.—The R.E. Survey Party will normally regard both "navigation" and "tie" strips as "navigation" strips. The distinction affects the flying problem only and is therefore used only by the Royal Air Force.

General considerations governing the Flying of "Navigation" Strips for Skeleton Maps

58. *Direction.*—As a general rule it is desirable to fly the actual "filling-in" strips east and west owing to the fact that on north and south courses northerly turning error and the sun render accurate compass flying more difficult. The shape of the "navigation" strip should therefore be planned to have the longer sides (AB and CD in fig. 7) running east and west respectively.

59. *Length of the four "Navigation" Strips.*—(i) Two separate factors have to be considered in deciding the size of the "navigation" strip rectangle:—

(*a*) Length.
(*b*) Breadth.

(ii) The *length* of the rectangle (*i.e.*, AB and CD, fig. 7) will be decided by the consideration of the factors affecting the length of the "filling-in" strips, which constitute the majority of flying. These considerations are discussed in detail in para. 69, but the most suitable distance may be stated as not less than 40 miles and not, normally, more than 60 miles.

(iii) The *breadth* of the rectangle (BC and DA, fig. 7) is less important, and is mainly governed by considerations of the ability of the crew to maintain sufficiently accurate courses to ensure the correct completion of the rectangle. 10 miles should be regarded as the minimum breadth, otherwise the number of "filling-in" strips necessary to complete the area will be so small as to render uneconomical the work of the R.E. Survey Party constructing the skeleton base map. 20 miles is regarded as a suitable distance. Practical consideration of the relationship between the height of the aircraft, focal length of lens, and size of negative will usually point to the most appropriate distances, *e.g.*, at 14,000 ft. with 7 in. lens F.8 camera, 50 miles = 46 exposures. At 14,500 ft. with 6 in. lens F.24 camera, 50 miles = 54 exposures.

60. *General.*—Care must be taken that the end photographs of each "navigation" strip overlap fully on the adjoining strip, as illustrated in fig. 7. If a partial overlap only is secured, the work of the R.E. Survey Party in constructing

the skeleton base map is rendered more difficult and its accuracy impaired. Particular care should be taken with the navigation and accuracy of these strips, as they have to be plotted with a minimum of " control," and will form the base map on which the accuracy of the " filling-in " strip will depend. The actual position of both " navigation " and " tie " strips for each case should be decided in conjunction with the R.E. surveyor, and arranged to fit in with " ground control ".

General considerations governing the Flying of " Tie " Strips for Skeleton Maps

61. The amount of " control " considered desirable for the flying of " filling-in " strips is the deciding factor in this case. If the number of " tie " strips is increased, then there is available a greater number of known points of which photographs can be taken into the air.

The chief considerations are :—

(i) The speed of the aircraft.
(ii) The visibility.
(iii) The nature of the country.
(iv) Skill of the crew.

62. *The speed of the aircraft.*—It has been found that if the full use is made of the reversed prism method described in para. 83, points should be visible ahead for not less than four minutes before passing over them ; after passing they can be checked back for a corresponding time. If less than four minutes is allowed the observer is apt to become confused. It must be remembered that he has to pick up the point of detail, note the error, if any, pass the correction to the pilot, and check on the amended course. It appears, therefore, that " controls " should be about 8 minutes apart with the average aircraft.

63. *The visibility.*—Poor visibility conditions will obviously tend to increase the difficulty of recognising natural features at a distance, and will require the " tie " strips to be placed at more frequent intervals. Average visibility will allow suitable objects to be picked up in the prism of the Aldis sight at about 8–10 miles.

64. *The nature of the country.*—If starting points on the track line of the navigation prints are of average detail it is possible to pick them up at 8–10 miles. The conditions in this case vary very considerably and no definite rule can be laid down until the type of country is known.

The strips should be arranged to pass over or follow any particular prominent ground features in the area, where this is practicable, having regard to other deciding factors.

It is not necessary that the " tie " strips should be at right angles to the " navigation " strips which they join, but they must be straight. It is not permissible that a tie strip shall be arranged to follow the winding course of a river, or road, as the resultant strip of photographs will not be suitable for use in the construction of the skeleton base map.

65. *Skill of the Crew.*—It is important that the same pilot and observer should always work together. It will be found, as experience is gained and the co-operation between the members of the crew improves that the amount of " control " required may be cut down.

66. *Conclusion.*—It is clear from the above considerations that no definite distance can be laid down for the mileage between strips, but, under average conditions, and with an aircraft having a speed of approximately 130 m.p.h. at survey height, that 15–20 miles is the best distance. The ideal distance is that which allows the observer to be in touch with either the past or the oncoming " control ", whilst also giving sufficient time to make good any corrections which may be necessary.

General considerations governing the Flying of " Filling-in " Strips

67. The " navigation " and " tie " strips having been completed in the best way possible, with due regard to the considerations outlined above, and checked for the accuracy indicated in para. 45, the prints are handed over to the R.E. Survey Party for the compilation of the skeleton base map. It will be found most convenient if this work is done at, or very near to, the R.A.F. Base, so that the loss of time is minimised.

68. *Navigation Prints.*—The navigation prints can be mounted and prepared for use in the air as soon as the skeleton base map is finished. Two sets of these prints will be required, for the pilot and observer, respectively. They should be clearly marked with the area number and run letter.

The particulars required on the prints are as follows :—

(i) Check point on the photograph over which aircraft should pass.

(ii) Track line.

(iii) Number of exposures to next " control " point in each direction.

(iv) Total number of exposures in " run ".

(v) True course.

(vi) Maximum permissible lateral error line. This should be fixed inside the actual 30 per cent. lateral overlap position to allow a small margin of safety. If it is

known that on the adjoining strip an error has been made causing the lateral overlap to be endangered, then the position of the appropriate red line should be moved in to conform.

A specimen set of navigation prints for one " filling-in " strip is shown in Appendix VI.

69. *Length of " Filling-in " Strips.*—The length of the " filling-in " strips, which must, of course, be decided before the " navigation " and " tie " strips are flown, is governed partly by the number of exposures available in the magazine, but mainly by the length of time which the pilot can be expected to maintain the necessary standard of accuracy in course keeping. This length of time will vary with the individual pilots, the amount of practice which has been possible, and the instruments used. Practical experience has shown that 40 miles can be flown without loss of efficiency, and it will, therefore, be undesirable to fly shorter lengths, owing to the increase in the number of skeleton base maps required. There does not appear to be any advantage in making the runs longer than 60 miles, unless the automatic pilot is used, in which case it may be desirable to cover the full distance allowed by the complete magazine for the height concerned.

METHODS OF FLYING

General

70. Each aircraft crew employed should be allotted a portion of the area to be photographed. This not only stimulates a spirit of competition, but, by constantly flying over an area, personnel gain local knowledge which would be wasted if they were given strips haphazardly. It cannot be too strongly emphasised that the closest attention must be paid to accuracy, both on the part of the pilot and observer.

Procedure on the Ground before Flight

71. In addition to the procedure laid down in Part I of this Chapter,

(i) pilot and observer obtain full particulars of the work required and decide upon the details of how it is to be performed,

(ii) check that the correct navigation prints are in the aircraft (if flying for " filling-in " strips),

(iii) check correct working of camera and see that all pilots' and observers' instruments are functioning properly, and

(iv) if flying for " navigation " strips and using " Normal " procedure outlined in paras. 72 and 73, work out the number of exposures required for each " run ".

Procedure in the Air before commencing Photography—Normal

72. *General.*—(i) While climbing to survey height, inspect the area to be photographed, and identify any points shown on navigation prints, or which can be identified by any other means.

(ii) Make two trial exposures on camera.

73. On reaching survey height the normal procedure will be to find the correct courses to fly to make good the predetermined tracks, also the correct time interval for the 60 per cent. fore-and-aft overlaps for the camera. The details of this procedure are given below. (Example of actual conversation in *italics*) :—

Pilot :	*Observer :*
(i) Fly straight and level at steady air speed, with aeroplane trimmed to fly "hands off", throttle adjusted, on the correct compass course, making no allowance for wind.	
(ii) Inform observer when steady on course—"*Steady on course 270*".	
	(iii) Level the Aldis sight.
	(iv) Set the instrument so that the prism shows the field of view astern.
	(v) Choose a prominent ground feature which is on the central line of the sight, and vertically below the aeroplane, and by rotating the tube of the sight keep this object on the centre line in the graticule. When the object passes out of the vertical field continue to follow it in the prism. Take a series of readings on the drift scale, and continue to follow the object for not less than five miles. The mean of these readings will give the drift.
	(vi) Give the pilot the drift reading in degrees, port or starboard—"*Drift 6° starboard*".

Pilot :	*Observer:*
(vii) Repeat back—" *Drift* 6° *starboard* ". Fly on the corrected course (for a port reading of the sight add to the compass course).	
(viii) Inform observer when steady on new course—" *Steady on course* 264 ".	
	(ix) Take a check reading of drift on the corrected course, and correct pilot again, if necessary.
	(x) Take the time interval for the correct 60 per cent. fore-and-aft overlap on this course by timing an object between the marked points of the graticule.

74. It is usually required for air survey purposes to fly on reciprocal courses. In this case, after finding the correct drift on the first course, apply equal and opposite drift for the second course, do a quick check run, and find the correct time interval.

Example.—Tracks required :—

(i) 90° Mag.
(ii) 270° Mag.

Drift to make good 90° = 8° port (i.e., pilot will steer 98° Mag.).

For 270° Mag. steer 262° Mag. and check result.

75. It is essential that the preliminary " runs " to obtain the drift should be made over a part of the country where the height of the ground is *known*, and is the same average height as the survey area. Otherwise the 60 per cent. fore-and-aft time interval obtained will be incorrect. *See also* para. 81.

Procedure in the Air before commencing Photography—Special

76. (i) There are two special cases in which it will be necessary to find the wind speed and direction and thence to calculate the correct courses and time intervals. Both are rare and need not normally be applied.

(*a*) When more than four separate and different compass courses are to be flown on the same flight.

(*b*) When " navigation " strips are to be flown over mountainous country, where the height of the

ground above sea level or aerodrome level is uncertain, and it is imperative that the tracks should be of exact length.

(ii) In case (*a*) it will be uneconomical to find the drift and time interval for a large number of different courses and therefore more satisfactory to calculate them on a course setting bomb sight, or new type course and distance calculator, after finding the wind speed and direction.

(iii) In case (*b*) it will be necessary to vary the time interval for the fore-and-aft overlap during the run, in order to keep the overlap constant at 60 per cent.; this will make it impossible to calculate the distance which the aircraft has travelled, unless the ground speed is known by calculation on the course setting bomb sight or new type course and distance calculator.

77. In both cases the procedure is as follows :—

Take accurate drift readings in the Aldis sight on three separate courses in the same manner as laid down for the three course method of finding the wind speed and direction with the course setting bomb sight. Using the new type course and distance calculator, or the course setting bomb sight, calculate the courses to make good the desired tracks and the time intervals for the normal 60 per cent. fore-and-aft overlap, also the time taken to fly the desired distance on each track.

78. The above described method takes longer than the normal procedure recommended in paras. 73–75 and is also likely to give errors due to the more complicated calculations required, especially at survey heights. It should therefore only be applied when the normal drift reading method cannot be applied.

Procedure in the Air when ready to commence Photography
(For " Navigation ", " Tie ", or " Filling-in " Strips.)

79. Having found the correct courses to steer to make good the desired tracks by one of the methods given above :—

(Example of actual conversation in *italics*, assuming track 90°—drift 6° port.)

Pilot :	*Observer :*
(i) Trim aeroplane straight and level so that it will fly " hands off " at the same throttle setting as was used for finding the drift.	
(ii) Inform observer when steady on any course—" *Level the camera* ".	

Pilot :

Observer :

(iii) Set correct drift for course on camera. Level the camera. Check the level of Aldis sight. Set correct drift for course on sight. Set counter on electrical control to NIL. Set time interval.

(iv) Inform pilot when ready to commence photography—" *Camera level* ".

Approaching the Start Point

(v) Fly on a course at right angles to the track, and at least two miles back from the start point. When the latter is at right angles to the line of flight, give observer " *Turning on* ". Turn on to correct course and inform observer—" *Course approximately* ", followed by—" *Steady on course* ", when compass has had time to settle and trim of aeroplane is absolutely correct.

(vi) As soon as " *Course approximately* " is received, commence to look for the start point, using the prism of the Aldis sight looking forward.

(vii) If start point is not on centre line of sight (with correct drift set) give "*Left* " or " *Right* " correction.

(viii) Respond to observer's correction by an S turn in the appropriate direction.

(ix) Inform observer when straight and level on correct course again, after a turn of this kind—"*Course approximately* ", " *Steady on course* ".

(x) If start point has been approached correctly it will now be on the centre line of

Pilot :

Observer :

the sight. If this is not so, cancel the run and start again. Give pilot "*O.K.*", or "*Wash out*".

(xi) If start point is on centre line of sight, switch on camera when point is vertically below. Give pilot —"*O.K., am switching on*".

Note.—Care must be taken before commencing the run to check that sufficient exposures are available to complete the strip, as it is not possible to change a magazine during a run.

Procedure for "Navigation" Strip Flying (assuming first course, 90°—drift, 6° port)..

80. Having passed over the start point as detailed above :—

Pilot :

Observer :

(i) Reverse Aldis sight, so that prism looks aft, with correct drift set. The start point should now be on the centre line of sight. Continue to observe the start point ; if it deviates from the centre line, adjust sight accordingly and give pilot amended drift reading (e.g., "*Drift* 4° *port*").

Note.—The above correction will normally be caused by a slight change of wind, assuming that the pilot steers an accurate compass course and that the drift was carefully taken on the preliminary runs. If more than 3° correction is necessary cancel run.

(ii) Repeat back amended drift—"4° *port*". Change course to 94°.

(iii) Inform observer—"*Steady on* 94".

(iv) Set correct drift on camera. Continue to check for drift throughout remainder of run. Check correct working of camera.

Pilot :

Observer :

Check levelling of camera. Check time interval. (*See* para. 47.)

Give pilot "*O.K.*" at one minute intervals.

(v) When the correct number of exposures for the length of run required has been made, switch off camera, take a careful note of the point on the ground vertically below the last exposure, and inform pilot "*Run finished.*"

Show finishing point of run to pilot ; this should be done by description accompanied by actual pointing.

(vi) Continue on course until observer, looking over the side of his cockpit, can point out the finishing point. Continue to circle until satisfied that this is point identified.

(vii) Fly straight and level for observer to set instruments for next run—"*Level the camera*".

(viii) Set correct drift for new course on camera.

Level the camera.

Set the correct drift on the sight. Set counter on electrical control to NIL.

Set time interval.

(ix) Inform pilot when ready to commence next run—"*Camera level*", and ensure that the second strip crosses inside the finishing point of the first run.

(x) Repeat procedure as laid down for the first run, and again for the third and fourth courses to complete the rectangle.

(xi) On the fourth (last) course, observer should use the Aldis sight, looking forward to pick up the original start point, and thus ensure that the rectangle is "tied-up" correctly.

81. *Time Interval.*—If the country is undulating, it will probably be necessary to vary the time interval slightly, which entails keeping a regular and careful check, but in this case there will probably be no means of knowing when the correct distance has been covered for the run. This may be found by :—

(i) Following " special " procedure to find the ground speed of the aircraft as outlined in para. 77, or

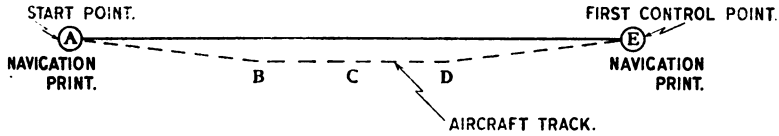
(ii) taking the time interval over a spot where the height of the ground is known, and estimating the time which the aircraft will take to cover the required distances.

Example.—Height of aircraft above ground, 14,500 ft.
Camera, F.8 type. Focal length lens, 7 in.
Time interval found to be 30 secs.

Now it is known that at this height, using this camera and lens, that 37 exposures = 40 miles. Therefore a 40 mile run will take 18½ minutes. A simple table can be prepared in a few minutes on the ground for use in the air. If considerable changes of height in the ground level occur it may be advisable to set a " short " time interval to cover all emergencies. If this is done before commencing photography a simple calculation will give the number of exposures required for the length of the strip. The procedure to be followed should be decided before flight, in consultation with the R.E. Survey Party, who can assist by giving all available information of the changes of height of ground in the area concerned.

Procedure for " Tie " Strip Flying

82. The start points from which " tie " strips will be flown will have been decided, having regard to all the considerations outlined in paras. 61–65. The flying procedure will then be the same as for " navigation " strip flying, up to and including para. 80, detail number (v).



CHAPTER IV, FIG. 9.—Aldis photograph sight. Method of control for " filling-in " strips.

Procedure for " Filling-in " Strip Flying

83. Having passed over the start point as detailed in para. 79 above (assuming track 90° and drift 6° port—*see* fig. 9).

Pilot :

Observer :

(i) Reverse Aldis sight so that the prism looks aft, with correct drift set. After passing start point (fig. 9,

Pilot :

(ii) Repeat back—" *Drift* 4° *port* ". Alter course to correct for the amended drift.

(iii) Inform observer when steady on new course—" *Steady on* 94 ".

Observer :

point A), continue to check it for alignment in the prism. If it does not remain on the centre line then the drift is incorrect. If more than 3° out, cancel the run. If slightly out, rotate the barrel of the sight until the start point (A) is on the centre line, read off the amended drift, and pass this to the pilot, *e.g.*, " *Drift* 4° *port* ".

Note.—This correction will normally take 3–4 minutes to determine. If such a correction is necessary the result will be to bring the aeroplane parallel to the correct track (BD). Set the amended drift on camera mounting. Check time interval. Check correct working of camera.

(iv) When it is estimated that the aeroplane has travelled half way to the first " control " point (*i.e.*, " tie " strip) the sight is reversed (Point C) so that the prism now looks ahead. Set the same number of degrees drift on the sight.

(v) Pick up the first " control " (Point E) in the prism. If it is not on the centre line of the sight, give pilot the estimated number of degrees left or right (Point D) so that the control will pass vertically below the aeroplane (Point E) *e.g.*, " 2° *left* ".

Pilot :

(vi) Repeat back—" 2° *left.*"

Alter course to 92° and inform observer—" *Steady on* 92 ".

Observer :

(vii) If the above corrections have been applied it will be obvious that unless the pilot receives a further correction at Point E the aeroplane will pass obliquely across the track. It will therefore be necessary for the pilot to return to the course which was steered between points B and D (*i.e.*, the amended correct course to make good the track).

(viii) On passing over the control point E the pilot must be given a correction which will bring him back to the correct amended compass course to make good the track, *e.g.*, " 2° *right* ".

The remainder of the flight on this course should now be correct, except for minor corrections due to change of wind, or inaccurate course keeping on the part of the pilot.

84. It is important that the correct working of the camera, and the levelling, time interval and drift, shall be checked as often as possible during each run.

85. It must be emphasised that the above method can only be applied successfully if the original drift has been found with accuracy. Any attempt to make good the track when corrections of more than 3° are required will fail, as the deviations from the correct track line will be considerable, co-operation between the pilot and observer difficult, and the lateral overlap of photographs with those of the next run endangered.

86. The outstanding advantage of the method, which appears somewhat complicated in writing, is that the observer is in touch with a known point during the whole of the run. This gives great material help and considerable moral support; it also enables corrections to be made before errors have become large enough to interfere with the efficiency of the result.

Chapter IV

Practical Fitting and Checking of Instruments, etc.

87. *Camera.*—(i) The survey camera to be used should be fitted in the standard position for the type of aeroplane. Care must be taken that when the camera mounting is set at zero the camera is aligned on the true fore-and-aft line of the aeroplane.

(ii) The camera should also be checked for "cut out", *i.e.*, that it is low enough in its mounting to ensure the full field of view from the aeroplane. It should be remembered that the usual lens used for air survey is of the wide angle type, and therefore will have to be fitted with the camera cross struts in the lowest position.

(iii) Attention is called to Chapter III, para. 11, dealing with the storage, care and maintenance of cameras. It is emphasised that cameras and all photographic fittings must be kept as free as possible from dust and sand, a large percentage of air failures being due to insufficient care in this respect.

Camera Equipment.

88. *Electrical control.*—The position for this instrument in the observer's cockpit requires careful thought. It must be easy of access while using the Aldis sight, but should be so placed that it cannot be switched off accidentally by contact with the observers' flying clothing. It does not work satisfactorily if placed on the floor of the cockpit.

89. *Pilot's light.*—This should be mounted high up in the cockpit so that it is within the pilot's range of vision during an actual photographic run.

90. *Accumulator.*—If required, this should be screwed down by wing bolts to avoid upsetting in the air.

91. *Camera leads.*—Care must be taken that any spare lengths of leads are carefully rolled and tied to the side of the cockpit. If due attention is not paid to this matter leads may be strained, causing electrical failure in the camera.

92. *Spares.*—A spare set of leads and spare electrical control should always be carried in a dust-proof box; this should be stowed, together with spare magazines, in the cockpit in such a position as to be easy of access when required, but not in the way of the observer during the flight.

93. *The Aldis Photographic Sight with Prism.*—The Aldis sight should be fitted in such a position in the observer's cockpit that it can be used easily, and if possible, with the observer in a sitting position. The sight must be lined up accurately on the fore-and-aft line of the aeroplane, and this

can be done as follows:—Set up the aeroplane in flying position. Drop a plumb bob from the nose and tail of the aeroplane, as for compass swinging, and draw a line joining these two points. Now drop a plumb bob from the centre of the hole cut for the sight. Draw a second line parallel to the first, cutting the position fixed by the Aldis sight plumb bob. This line will be the fore-and-aft line vertically below the sight. Now fit the Aldis sight and level it. Using the prism to look forward, and then aft, check the alignment of the sight by means of the centre line of the graticule. If out of line, pack up the wedge plate until the correct position is found. The Aldis sight should not be fitted until the aeroplane has left the ground and should be removed before landing owing to the risk of damage by small stones, etc.

94. *Statoscope and Pitch and Yaw Indicator.*—These two instruments must be fitted high up in the pilot's cockpit for the reasons already given in the case of the pilot's light.

95. *Air Speed Indicator.*—The air speed indicator should be carefully calibrated.

96. *Compass.*—The compass, as already explained in para.52, should be capable of reading to 1° with accuracy and free from excessive deviations. A careful swing on 16 points must be made, and the result recorded as a graph in the pilot's cockpit. Readings should be checked at frequent intervals.

97. *Flying Clothing and Personal Equipment.*—The clothing of the crew must be appropriate for the temperature at which the survey flight is to be made, as personal comfort is essential to enable the best results to be obtained. Sidcot suits, parachute harness, etc., should be carefully selected and fitted. Flying helmets fitted with telephones must be comfortable.

98. *Intercommunication.*—Properly fitted telephones are essential to establish the perfect co-operation between the pilot and observer which is necessary to ensure the success of this type of work. Telephones should be inspected before every flight to ensure correct working. Failure in the telephone system is a most frequent cause of poor results in the air and can only be avoided by careful inspection on the ground.

Weather

99. There is one factor in considering air survey which cannot be overlooked—the weather conditions. It will be noted that the surveyor specifies that the photographs should be taken at as high an altitude as possible, and that 14,500 ft. above ground level has been stated as a most suitable height under present day conditions. In effect, this means that the

photographs have to be taken when the sky in the area concerned is free from all cloud, except perhaps stratus or cumulostratus. In most countries these conditions are found comparatively rarely, and often only locally; it is, therefore, of the utmost importance that the meteorological information available at the R.A.F. base should be accurate, and that the aerodrome should be as near to the photographic area as possible. When the aerodrome is at a distance, every effort should be made to establish telephonic communication with a reliable observer in the area. Neglect to observe these precautions always leads to loss of valuable flying hours and causes needless loss of time in completing the survey work. It may be that, under war conditions and with the improvements in cameras or methods of plotting, survey flying can usefully be undertaken at lower heights, but in any case the importance of obtaining accurate weather reports will remain.

Camera Calibration

100. The need for calibration of a survey camera is shown in para. 39 above. Before commencing photography arrangements must be made with the R.E. Survey Party to undertake this work. It will usually be necessary to calibrate each camera before and after a survey. A set of special calibration plates cut to the size of the camera, and also a levelling table, must be obtained. The actual calibration photographs should be taken at the R.A.F. base, in order to facilitate dark-room work, and because it is important that the camera should be disturbed as little as possible after the completion of the calibration and during the survey itself. An account of the field work to be carried out by the survey party and R.A.F. personnel concerned will be found in Chapter IV of the Professional Paper No. 8 of the Survey Committee, a copy of which should be in the possession of any unit undertaking air survey work.

Ground Organisation

101. *General.*—A very careful check of the lists of photographic equipment, stores and accessories should be made, having regard to the local conditions, as soon as it is arranged that survey work is to be undertaken. Particular points to note are the supply of adequate spares, regular supplies of freshly-coated film and paper, a good supply of suitable water, which can be used at working temperatures, and the electrical light supply.

102. *Reconnaissance Reports* R.A.F. Form 2047.—These must be filled up immediately after flight. The original will be filed in the photographic section, and the duplicate filed with the film in storage.

103. *Negative Register R.A.F. Form 2052.*—It will be found convenient to keep a register showing the following detail :—

Film serial number.

Reconnaissance report number (usually the same).

Film batch number and date of coating.

Camera number.

Magazine number.

Date exposed.

Subject (area number, run letter).

Light conditions.

Shutter tension.

F. stop number.

Time and temperature of development.

Numbers of prints accepted, with particulars.

Detail of supply of prints.

Remarks.

104. *Camera Log Books R.A.F. Form 2050.*—These must be kept up to date and in detail, as they are often of great assistance in locating mechanical defects.

105. *Key Map.*—One to be kept, marked up to date, in the photographic section, and one to be kept by the R.E. Survey Party.

106. After the film is developed one print of every exposure is to be made and passed to the pilot and observer, together with a copy of the reconnaissance report. Pilot and observer, in conjunction with the photographic section, pin the strips together and satisfy themselves as to the lateral overlap and quality of the flying, mark on the back of each print the run letter and serial number in the run, *e.g.*, F/1, F/2, etc. The photographic section then mark the runs on the key map in pencil, as completed, check the levels, print the necessary number of copies, enter up the register, forward a set of prints to the R.E. Survey Party, and pass the film to storage. The set of first prints should be kept in the photographic section for future reference.

Training

107. The success of flying for air survey depends mainly upon accurate navigation, and, in order to train personnel for this work, flights should be made over mapped country to ascertain the magnitude of errors to be expected in order that the lateral overlaps between " filling-in " strip runs and the distance between " tie " strips may be adjusted accordingly.

Chapter IV

108. *Fundamental Training.*—A study of the fundamental principles underlying air survey. This study should be confined to elementary matters and should be just sufficient to enable flying personnel to appreciate the surveyor's problems and understand the reasons underlying the surveyor's demands.

109. *Ground Training of Flying Personnel.*—(i) Instruction in the principles of D/R navigation and use of navigation instruments.

(ii) Calibration of instruments.

(iii) Use of instruments.

(iv) The art of accurate flying (using compass and pitch and yaw indicator).

(v) Calculation of course, ground speed and time interval for 60 per cent. overlap.

(vi) Marking of " navigation " strips for mosaic flying.

(vii) Working out an organised scheme for a photographic survey.

(viii) Methods of procedure to be followed in the air.

110. *Air Training of Flying Personnel.*—(i) Determination of drift.

(ii) Determination of wind speed and direction.

(iii) Practice in steady flying over comparatively long distances, overlap photographs being taken during flight.

(iv) Practice in steady flying over comparatively long distances, on a given track, starting from a known point, overlap photographs being taken during flight.

(v) Laying down " navigation " strips and " tie " strips with navigational control.

(vi) Marking up " navigation " strips and flying with their assistance.

Note.—The above syllabus takes no account of the training already carried out by R.A.F. units. It will be found that much of the ground is already covered by normal navigation, bombing and photographic training. Air survey training will consist of the proper co-ordination of these subjects.

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CHAPTER V

AIR PHOTOGRAPHY IN CO-OPERATION WITH THE ARMY

Responsibility for Air Photographs

1. A large proportion of air photographs taken during the course of military operations are obtained at the request of, and for the use of, military commanders and formations. In such circumstances the air force is concerned only with the production of the negatives and the initial issue of prints. The responsibility for the interpretation and distribution of such photographs rests entirely with the army.

2. In order to ensure that the closest liaison is maintained between air force units and the army formations with which they are co-operating, certain army officers, known as Air Liaison Officers, are attached to squadrons. These officers are responsible for plotting all photographs taken for military intelligence purposes, for deciding which negatives shall be printed, and for estimating the number of prints required from each negative.

3. The type of unit most concerned with the production of air photographs for the army is the army co-operation squadron and full details regarding the procedure to be carried out in such squadrons are contained in the A.P. 1174 Manual of Army Co-operation.

4. The duties of the I.L.O. with regard to air photographs are laid down in A.P. 1176 Manual of Army Co-operation.

5. When squadrons, other than army co-operation squadrons, are required to obtain air photographs for military intelligence purposes, as in the case of a day bombing squadron allotted for long distance reconnaissance duties, the interpretation, plotting, and distribution of prints is carried out at the headquarters of the formation to which the squadron belongs, unless an Air Liaison Officer is attached to the squadron.

Chapter V

Channels of Demand and Supply

6. The channels through which demands from the army for air photographs should pass are laid down in the A.P. 1176 Manual of Army Co-operation, and are, briefly, as follows :—

" The A.O.C. will advise the military commander in the field the distances up to which the different types of squadron will be responsible for photographic reconnaissance.

" When a squadron has been allotted to a division for any operation and the squadron is receiving its orders from the divisional commander, demands for air photographs required by him will be made direct to the squadron commander concerned, through his Air Liaison Officer. In this case the squadron commander must, when possible, notify the wing commander what photographic work is in hand, so that there may be no duplication of effort.

" When photographs outside this area are required, or when squadrons are retained under corps control, demands will be made through corps headquarters on the army co-operation wing, which will co-ordinate the work and allot tasks to squadrons. Demands for photographs required outside the area for which the army co-operation wing is responsible, will be forwarded to the next higher formation concerned."

7. All demands for air photographs will be dealt with at squadrons by the Air Liaison Officer, who will supply the required number of prints direct to those concerned.

8. Distribution of prints will be carried out under local arrangements, and the method will vary with circumstances and with the facilities available.

Method of Demanding Air Photographs*

9. The necessary information which must always accompany a demand for air photographs is as follows :—

(i) Particulars regarding the place, or areas, of which photographs are required. Map references must be given whenever possible.

(ii) Whether vertical or oblique photographs are required.

(iii) A brief description of the purpose for which the photographs are required, or, if this cannot for any reason be given, the approximate scale of prints desired.

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* *See also* A.P. 1633, paragraphs 16–20.

(iv) Order of priority of the demand in relation to other demands submitted previously, or at the same time.

(v) Distribution list showing the number of prints required, and to whom they are to be sent.

10. The height from which the photographs are to be taken is entirely a matter for the squadron commander to decide, and should not be specified in the demand. A print of approximately any desired scale can be produced by fitting lenses of different focal lengths to the camera used, and by enlarging or reducing the image on the negative obtained. The height at which it is possible to take air photographs is governed largely by the existing weather conditions, and to a certain extent by the degree of enemy interference likely to be encountered during the flight. It is, therefore, essential that the manner in which air photographs are obtained should be left to the squadron concerned. It will, however, be of great assistance to the squadron commander in deciding the type of lens which must be used in any given circumstances if he is informed of the purpose for which the photographs are required. He will then know whether large detail over a small area, or the reverse, is the object to be attained, and can make his arrangements accordingly.

11. On occasions when, for reasons of secrecy, it is not considered advisable to state the purpose for which the photographs are required, the approximate scale to which the prints should be made must be given. As the production of prints to an exact scale cannot be carried out with any degree of rapidity, and as there is rarely any necessity for this to be done, photographs can conveniently be divided into three classes as follows :—

" Large Scale "	1/6,000 to 1/10,000
" Medium Scale "	1/10,000 to 1/14,000
" Small Scale "	1/14,000 to 1/20,000

These classifications should be sufficient for all normal purposes, and should always be used unless some very special reason exists for requiring prints to an exact scale.

In special circumstances, photographs of a scale outside the above limits can be provided, but larger scale photographs should be limited to pin points and short line overlaps.

12. In order to ensure uniformity, and to avoid the possibility of the omission of necessary information, it is advisable that a standard form of demand should be employed. Although circumstances may necessitate minor alterations in the actual form, the specimen demand shown on page overleaf fulfils all requirements and should be taken as a guide.

DEMAND FOR AIR PHOTOGRAPHS

Priority No. *2.*

Serial No. : *27.*
Date : *5-7-26.*

From :—*III Corps.*

Map Sheet.	Description and Map Reference.	Vertical "V" or Oblique "P."	Purpose for which required, or Scale.	Total No. of Prints.	Distribution.		Remarks.
					No. of copies	To be sent to :—	
XXI	*Pin Points.*				*5*	*Hqrs. III Corps.*	
	K. 27, 42.	*V*	*To confirm the existence of camouflaged battery positions.*	*30 of each.*	*3*	*,, 2nd Divn.*	
	K. 31, 37.	*,,*			*3*	*,, 7th Divn.*	
	K. 59, 64.	*,,*			*2*	*,, 5th Inf. Bde.*	
	K. 81, 25.	*,,*			*9*	*,, 2nd FA. Bde.*	
					8	*,, 4th F.A. Bde.*	
	J. 01, 30.	*,,*	*Large Scale.*		*30*		
	J. 97, 55.	*,,*					

J. Humphry, Maj.,
Signature of Demanding Authority.

To :—*Hqrs. 2nd (Army Co-op) Wing, R.A.F.*

13. Each definite photographic task, irrespective of the number of actual photographs involved, must be entered on a separate demand sheet. These sheets will be numbered in order of priority by the demanding authority daily. Demands which, for any reason, have not been fulfilled on the day of issue must, if still required, be repeated on successive days, and must be numbered in order of priority in relation to any new demands, which may also be submitted.

14. When demands are received at the headquarters of the R.A.F. formation which includes two or more squadrons, the staff, after allotting task, will pass on the demand sheets to the squadrons concerned and will mark those allotted to each individual squadron in the required order of priority.

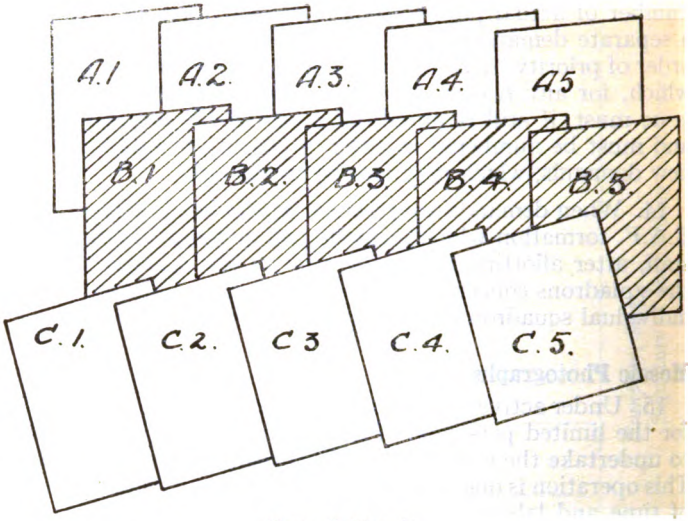
Mosaic Photographs

15. Under active service conditions it will seldom be possible for the limited personnel of a squadron photographic section to undertake the construction of finished mosaic photographs. This operation is one which requires a considerable expenditure of time and labour, and the delay involved would, in many cases, render it impossible to supply the mosaic early enough for it to be of any value. In addition, the withdrawal of photographic personnel from routine duties would have an adverse effect on the speed of production of ordinary prints.

16. On the majority of occasions when a photographic reproduction of a large tract of country is required, a set of overlapping prints which cover the area concerned and which can be put together by the recipient will be sufficient to fulfil all requirements. In order to facilitate the piecing together of loose prints by persons unused to the appearance of air photographs, a system will be employed whereby the position of each print in relation to the others is indicated by a letter and a number. These will be marked in pencil on the back of each print as follows :—

17. Each row is given an index letter. The first row is given the letter " A," and each print in that row will be numbered consecutively thus :—" A.1," " A.2," " A.3," etc. The second row is given the letter " B," and the prints in that row are also numbered consecutively, starting with the number " 1." Successive rows are marked in a similar manner. An example of this method of marking is shown in the diagram given below.

18. An additional advantage of this method is the fact that the whole of each print is available for examination, and that the possibility of the loss of important detail at the edges owing to the cutting or to the incorrect superimposition of overlapping portions is consequently avoided.



Type I Mosaic.

A set of loose, overlapping prints of this nature is termed a " Type I Mosaic." A finished production in which the prints are cut, fitted together, and mounted on a permanent base, is known as a " Type II Mosaic." These classifications should always be employed when submitting demands for mosaic photographs.

Chapter VI
of
AIR PUBLICATION 1354
(*Issued February*, 1936 *with A.L.* 3)

CHAPTER VI

AIR PHOTOGRAPHY IN CO-OPERATION WITH THE ROYAL NAVY

General

1. Although air photography affords a valuable means of obtaining naval intelligence under certain circumstances, it is not of such paramount importance to the Royal Navy as a whole as it is to the Army. Aircraft operating with the fleet in the open sea can obtain little useful information by means of the air camera, although it is sometimes of value for confirming observers' reports of occurrences such as the presence of enemy submarines or surface craft in certain localities at certain times. On the other hand the employment of cameras on air reconnaissances of enemy harbours and coast lines is essential, the type of information required in these circumstances being similar in many respects to that obtained by reconnaissance over land for military purposes. Further, when combined operations are being undertaken by two or more of the services together, the carrier-borne aircraft operating with the fleet will normally be responsible for all air reconnaissances of enemy territory until such time as a suitable land base has been secured from which the army co-operation squadrons can operate. During this period air photographs will be required by both the naval and military commanders, and the personnel of the Fleet Air Arm must therefore be capable of undertaking this work in addition to their other duties.

2. In time of peace, air photography is used extensively by the Navy in connection with gunnery and torpedo training, photographs of the fall of shot round a target, and of the tracks of torpedoes, being of considerable value to those responsible for directing such operations.

Responsibility for Air Photographs

3. Just as in the case in army co-operation, R.A.F. personnel and units working with the Navy are only responsible for the production of air photographs, the work of interpretation being the duty of the naval staff. Instructions as to what photographs are to be taken are issued by the commander-in-chief of the fleet, and the detailing of any particular carrier o

capital ship to despatch aircraft to carry out the work is also undertaken by him. The actual taking of the photographs is the duty of the flying personnel, and the production of prints is done by the R.A.F. photographic section in the aircraft carrier, the finished results being despatched to the commander-in-chief's staff for further action.

4. In view of the close co-operation which naturally results from the fact that naval aircraft and their crews are carried in ships of the fleet, no system of liaison officers, similar to the Branch Intelligence Officers attached to army co-operation squadrons is necessary. When, however, carrier-borne aircraft are required to co-operate with land forces in the course of combined operations, and to obtain air photographs on behalf of the military staff, it will usually be advisable for an army A.L.O. to be attached to the ships concerned for the purpose of co-ordinating the work, and of extracting the desired information from the results obtained.

Organisation.

5. As the Fleet Air Arm is an integral part of the Royal Navy, the responsibility of the Royal Air Force as regards the organisation of photographic work goes no further than the individual photographic section. Each aircraft carrier is equipped with a photographic section, the work of which is carried out by R.A.F. personnel under the control of a suitable officer.

6. The work of these sections is practically identical with that carried out by normal squadron sections, and the organisation is therefore the same in principle. The provisions of Chapter III may therefore be taken as applying equally to both, subject of course to such modifications in procedure as are necessitated by the difference in the conditions prevailing in a ship to those experienced at a land aerodrome.

7. The organisation of air photography in shore-based units of the Royal Air Force which, although required to undertake duties in co-operation with the Navy, are under the direct control of the Royal Air Force, is in accordance with the principles laid down in Chapters II and III.

Chapter VII
of
AIR PUBLICATION 1854
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CHAPTER VII

INTERPRETATION OF AIR PHOTOGRAPHS

General on Types of Photographs

1. *Difference of type.*—Photographs taken in the usual way from a ground station are used to illustrate the view from O.P.'s or to accompany reconnaissances or reports. The view they give is that usual to the eye, and objects in the foreground are naturally larger than those in the distance. A photograph taken from an aeroplane with the same horizontal axis would show little but sky. Air photographs are taken therefore with the camera depressed below the horizon (obliques) or pointing straight downwards (verticals). Neither appear quite natural to the eye. A mental picture of the difference will be obtained by thinking of a few chessmen on a chessboard. Putting the eye at the level of the board, the chessmen are seen in elevation (ordinary ground photograph). Looking sideways and from above, at an angle of about 45° the chessmen are foreshortened, and the square of the chessboard are seen in perspective (obliques). Looking directly down on to the centre of the board the squares look correct and are no longer in perspective, but the chessmen are seen in plan only—(vertical).

2. *Value in examining ground.*—(i) The value of obliques and verticals in the examination of ground is seen clearly from the analogy of the chessboard. The oblique shows more of the ground than can be seen from any ground station, and it shows hill features and objects in a way more or less familiar to the eye, although not so well as from a ground station. The vertical shows the ground in plan, and no detail, except under trees or artificial cover, escapes notice. The oblique is useful in showing the natural difficulties of nature—hills, ravines, defiles, and the best covered line across country. The vertical shows more clearly still local difficulties, such as water, marsh and plough, and the details of towns, villages, railways, roads, tracks, canals, earthworks, etc., but gives practically no clue to hills, valleys and contours generally.

(ii) Photographing from a ground station it is possible to take a series of overlapping views, which, joined together, form a complete panorama. The same would be possible for " obliques " from an aeroplane if a sufficient number of cameras could be used simultaneously and at the same angle to the horizon—with a single camera it is not possible because the aeroplane travels too fast (and therefore too far) between

exposures. Verticals, however, being nearly (though not quite) correct in plan can be joined up to make a combined picture or mosaic of a large area. Mosaics provide a useful guide to country, but, like single verticals, do not show heights.

3. *The Stereoscope—general.*—In the preceding paragraphs photographs were considered singly (even in mosaics there is only one single picture of any one small area). In this single form they represent what one eye would see from the position of the camera. Normally, however, we use not one but both eyes, and we are able to measure distance, and to appreciate shape and form because of the distance between the pupils (about 2½ in.), which is the " base " of the human range-finder. The base being small, normal vision has " stereoscopic " or range-finding power which extends for not more than 300 yards. Beyond that limit distances are judged by relative size and clearness. The same stereoscopic effect (but extending to much greater distances) is to be got from two photographs of the same object taken from different points of view* and seen through a stereoscope. The photographs must, however, be taken at about the same distance, from and at about the same angle to, the horizon. The use of a stereoscope alters the respective values of the oblique and the vertical. Supposing that two verticals are taken at about a distance of 1 mile from each other in the air, then the " overlap " between them (about half of each photograph) will show the same country from two points of view. Looked at in the stereoscope this overlap is seen in the form of a raised model on which tactical features and ordinary detail are brought out equally clearly, and in which the respective advantages of oblique and vertical are combined.

4. *Types of Photographs.*—Photographs may then be considered under the following headings :—

(i) Ground photographs (including panoramas) : These require no further explanation.

(ii) Obliques : Always used singly.

(iii) Verticals :—

(*a*) Single

(*b*) Made up in mosaic form.

(*c*) Used in pairs with the stereoscope.

Note.—With (i) and (ii) it may be possible to use the stereoscope, but so rarely as to make it unnecessary to go further into the question. On the other hand, with (*c*) a stereoscope is easy to use and adds largely to military value.

* No stereoscopic effect is possible without different points of view. For example two copies of a map or two identical photographs can give no stereoscopic effect.

5. *Use of maps.*—Any photograph, of whatever type, deals with a small portion of the ground, and is undefined in scale and orientation. Like the thumbnail sketches which accompany a report, photographs must be studied with the map. The map is the authority for distances, bearings and the general tactical features of the ground. The photograph adds local information both of topography and of the dispositions of the enemy. Maps and photographs are, therefore, complementary and must be used together.

6. *Obliques.*—Obliques represent a sector bounded by lines which start at the camera and open out (at an angle which may vary from 40° to 60°) to the horizon. Each oblique therefore illustrates the view from a single point, and is not correct for any other point of view. It is useful, as a general guide, for any point within its sector, but must not be taken as correct in direction or relative distance except from the point above which the camera was exposed. That point will never be known accurately, however, and it becomes more than ever essential to use the map at the same time. Obliques are most useful in orienting the line of attack. Since the view of an ordinary oblique is very similar to that which might be seen from the top of a mountain, no special instruction in its use is necessary. If, however, the oblique is depressed much below the horizon objects will tend to appear more in plan than in elevation and the remarks of the succeeding paragraphs on verticals will be found useful.

7. *Verticals.*—Verticals, as being at once easiest to take from a military point of view, and most useful for all topographical and military purposes, form the bulk of photography on service. They show the ground from an unfamiliar point of view and require special explanation, but it must not be forgotten that common sense is the chief requisite for their study. If it is remembered that everything is in plan and if one or two verticals are compared on the ground with the country represented, little difficulty will be found thereafter. Verticals are used for the following main purposes :—

(i) *Examinations of tactical features.*—In some cases photographs are used as a substitute for large-scale maps for particular operations. In others they are studied for the particular needs of different arms, as, for example, the topographical obstacles to tank movement.

(ii) *Intelligence.*—Commonly dealt with under the heading "interpretation," this point will not be enlarged upon. It is a matter of common sense, training, and knowledge of contemporary tactical method.

(iii) *Mapping.*— Of interest to army technical troops only, except in so far as it is dealt with for sketching purposes in Chapter XVI of the Manual of Map Reading.

8. *Data required for use of verticals.*—Before using a vertical photograph, certain facts regarding it must be known. These facts are much the same as in the case of a map, but include one important addition in the direction of the light and consequently of the shadow cast by tree, house or any other vertical object. Thus, as with a map, it is necessary to know :—

(i) the position or area illustrated.

(ii) the scale.

(iii) the orientation.

(iv) the serial number (for reports, or for further demands); and in addition :—

(v) the direction of light.

(vi) what objects look like when photographed from above.

To provide as much as possible of this information, the following data are given in the margin of a photograph taken with F.8 camera.

(*a*) Time of exposure.
(*b*) Height of exposure (above level of aerodrome).
(*c*) Date.
(*d*) Focal length of lens.
(*e*) Unit taking photograph.
(*f*) Levels.
(*g*) Serial number of photographs.

As explained below :—

(i) is found by comparison with the map.

(ii) can be deduced from (*b*) and (*d*) and must be verified from the map.

(iii) can be deduced roughly from (*a*) if the direction of light and shadow (v) can be seen clearly on the photograph.

(iv) is the unit (*e*) and the serial number (*g*).

(v) can be deduced from (*a*) if the orientation has been found from the map, or it can be found by inspection of the shadows on the photograph itself.

(vi) is a matter of common sense and of the principles given below.

If old patterns of camera (not equipped with the " data " panel of the F.8) are used, information is generally inscribed by hand on the negative. In all cases the necessary information can be got by comparing photograph and map. Where time permits, the grid position of each photograph is given on its reverse side by the Intelligence Liaison Officer.

9. *Identification.*—Identification of the area covered is perhaps the greatest difficulty. The photograph is generally on a much larger scale than the map, which may be out of date, or so much generalised as to afford little clue to the position of individual prints. If a series of photographs is available, proceed as follows.—Examine on the map the area over which the aeroplane was photographing. Pick out one or other of the following :—

(i) Railways.

(ii) Roads with characteristic bends, corners or junctions with other roads. A long and more or less straight stretch should be chosen.

(iii) Rivers and canals of well-marked shape or junction and sufficiently straight and long.

Identify a photograph of some portion of the chosen object and then proceed to follow along the same feature until three or four photographs have been correctly placed and the scale has been roughly gauged. Now look on the map for towns, villages, lakes and woods in reference to the railway, river, or road originally chosen and place other photographs roughly in position until all have been located. With a single print it will be found best to choose some large and well-defined object in the photograph and to look for it on the map.

10. *Scale.*—(i) Only in perfectly flat country will the scale be constant over the whole area. In mountainous country the scale will vary and can only be ascertained approximately. The top of a mountain is nearer to the camera than its base and appears therefore at a larger scale. In undulating country the variations in scale will not be noticeable for practical purposes, but supposing that the general level of the country is higher on one edge of a photograph than the other, the effect may be very marked. For example, if a straight line of railway appears on the left edge of a strip of several photographs and the country rises from it to a line of hills on the right edge, the photographs if fitted together, will tend to form a circle and the railway, actually straight, will bend at each join. In no case, then, can the deduced scale be anything more than the view scale over the area in question.

(ii) The only method of obtaining a true scale is to compare the distance on the photograph between two objects with the distance on the map (or ground) between the same two objects. As a simple example, the distance measured on a photograph between a certain road junction and a railway bridge is 3 inches and from the map it is found that the distance between the same point is 1 mile. There the scale of the photograph is 3 inches to a mile.

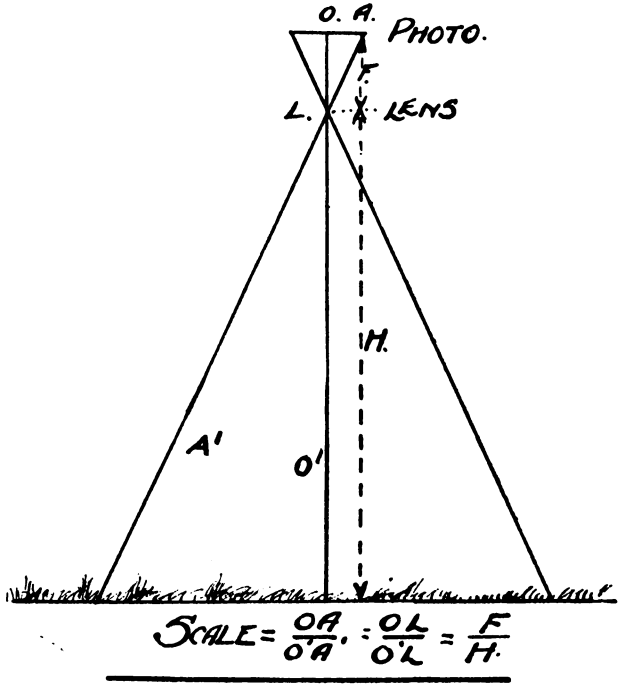
(iii) The scale may be obtained approximately by measuring on the photograph the size of objects such as width of road or railway, houses, etc., the actual size of which is known, or

(iv) by obtaining the R.F. from the formula

$$\frac{\text{focal length of lens (F).}}{\text{height (H).}}$$

Both factors are given in the " data " panel on the photograph (*see* para. 8) but both must be in the same unit-example—F. (focal length) 10 inches, H. (height) 12,000 feet. Then scale is $\frac{10}{12}/12{,}000$ or $\frac{1}{14400}$ (about 4 inches to the mile).

The scale thus obtained is that of any ground at the level of the aerodrome.



CHAPTER VII, FIG. 1.

This R.F. will be the scale of the photographic negative (or contact print) and therefore it must be known whether the photograph being dealt with is a contact print or an enlargement. If an enlargement, the R.F. must be adjusted accordingly.

11. *Orientation.*—Where photographs have been "placed" on the map the orientation follows as a matter of course. Where they have not been placed, shadows must be studied in conjunction with the time of exposure (para. 8). It is often difficult at first to identify the direction of shadow. For example, an avenue of poplar trees will cast shadows which are often taken to be the trees themselves (the latter appearing as small dots at the ends of the shadows, easily identified in the stereoscope but difficult to pick up on individual prints). Nevertheless, trees and houses are the safest guide to direction of shadow. If they do not exist on the photograph look for bridges, or telegraph or other poles. It is but a rough orientation which can be obtained in this way, and a rough idea of where the sun was at the time of exposure will suffice. Cuttings and embankments are dangerous as a guide to shadow because, as will be explained later, they may be confused with each other if the photograph is not placed in its correct position relatively to the window or source of artificial light.

12. *Direction of light.*—At the time of exposure the sun casts shadows in a direction due to its position at that moment. In studying the photograph afterwards the light from window, or artificial source, must be made to fall on the photograph in the same direction as did the sun's rays on the ground. If shadows appear to point towards, instead of directly away from, the light the effect is so contrary to nature that embankments look like cuttings and mounds like holes. This rule then, "reproduce the lighting conditions of nature" applies to any vertical photograph, single mosaic, or stereoscopic pair, and misleading or inferior results will inevitably occur if it is not followed.

13. *Objects of characteristic shape.*—Even though colours are not represented, except in tone, on the photograph, certain features are unmistakable. The straight lines and even curves of railways, the buildings of a town, the roads (generally whitish in tone) the water (generally black or dark grey) and woods are at once recognisable.

14. *Colour and light.*—To understand the general appearance of country, two factors affecting the photographic tone or depth must be appreciated. These are:—

(i) Photographic tone value of colour.
(ii) Reflection of light.

Thus, a road will look different in tone according as the surface varies in colour (tar, macadam, etc.), and according as that surface reflects light to the camera.

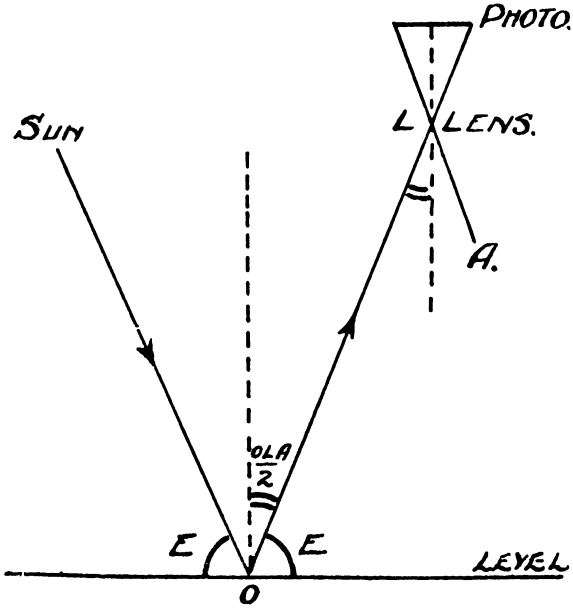
15. No colours are given on the photograph, but each colour has its corresponding tone (or darkness) somewhere intermediate between black and white. Thus, a patch of poppies in corn would appear black against a mottled lightish background,

and pasture is substantially darker in tone than stubble. The effect of photographic tone is, however, modified and often negatived by the greater effect of reflection.

16. (i) The more light reflected by an object the whiter does it appear on the photograph. The amount of light reflected depends on the nature and texture of the surface and upon the angle which that surface makes with the sun's rays and the photographic plate.

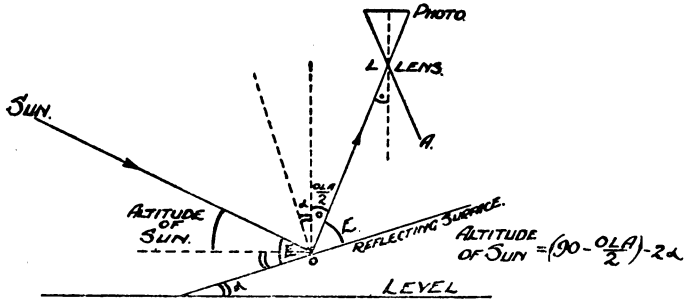
(ii) Light striking a perfectly smooth surface at an angle of E (angle of incidence) is all reflected at the same angle (fig. 2); if the camera lies in the path of the reflected light, the object will appear white on the photograph; if it does not, the appearance of the image of the object will depend on its colour. The amount of light reflected according to this rule depends on the degree of smoothness of the object.

(iii) Smooth water, which reflects most of the direct light falling on it, may be taken as a simple example. In fig. 2 the angle O L A represents the range of a camera taking a vertical photograph. Light will only be reflected on to the photograph when E is equal to or greater than $90° - \frac{OLA}{2}$ $\frac{OLA}{2}$ depends on the camera in use, but will not be more than 30°. Therefore, the sun will only be reflected on to the photograph from smooth water, when at an altitude of 60° or more, and it will then appear as a white patch merging off gradually into black, the usual photographic tone of water.



CHAPTER VII, FIG. 2.

(iv) But all reflecting surfaces are not level, and, no matter what the altitude of the sun may be, there may be some that will reflect light on to the photograph, e.g., glass roofs, roads on hills, etc. In such cases the same rule of reflection applies, as shown in fig. 3.



CHAPTER VII, FIG. 3.

(v) This argument can now be applied to irregular and rough-surfaced objects whose surfaces can be considered as consisting of a number of reflecting surfaces of various sizes inclined at different angles to the level. The nature of the object will determine the quantity and size of such surfaces and the possibility of any of them reflecting light direct to the camera.

(vi) Objects that partly reflect light to the camera will appear lighter on the photograph than the image of their natural colour. Examples will be found in para. 17.

(vii) The preceding sub-paragraphs will explain why tracks are so easily picked up on air photographs. The earth, grass or vegetation is crushed flat so as to alter the reflection of light, whilst in many cases the straightness and evenness of the track or path gives an additional clue.

17. *Examples of the appearance of topographical features on vertical photographs.*—(i) *Roads, tracks and paths.* (*a*) Roads are, in general, of uniform width and run in straight stretches of varying length with regular bends. Sharp bends will usually only be found in broken country where embankments, cuttings and bridges are also more frequent. Tracks and footpaths tend to be more uneven in width and twist more than roads. In low-lying, damp country this is particularly evident as tracks and paths deviate round minor obstacles which would be cleared away for a road.

(*b*) Tarred roads, owing to their colour, should appear black, but as they reflect indirect light appear dark grey. Where the sun is reflected directly to the camera the road appears white, shading off to grey again on each side of the reflecting point. Usually there is a narrow light strip down each side of the road, caused by the accumulation of dust on

the least-used parts and by the greater reflecting power of the sides of the camber.

(*c*) Macadamised roads, owing to their colour, appear light grey approaching white. The surface, though rough, is flat, and therefore reflects indirect light, to some extent adding to the light appearance. The rough surface does not reflect the direct rays of the sun so much as a tarred road, and it never appears such a dazzling white.

(*d*) The width of roads cannot be measured with certainty, as the edges, which are least used, merge into and are lost in grass margins.

(*e*) Unmade roads, tracks and paths appear in the same tone as macadamised roads. When little used they are slightly darker, as the rougher surface is a poorer reflector. Wheel tracks appear as two light lines. A central line of slightly lighter tone (see fig. 4) implies horsed traffic.

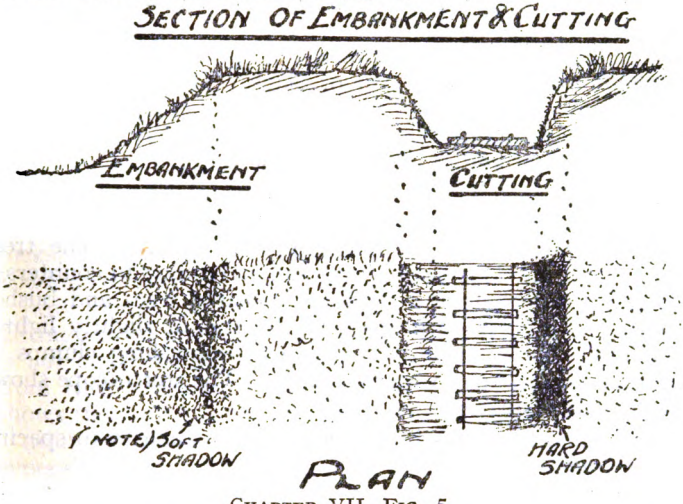
Chapter VII, Fig. 4.

(ii) *Railways.*—Distinguished by dead-straight lengths and regular curves (more regular than on roads). Width is uniform and, in highly developed countries, embankments and cuttings are frequent. In hilly country curves are more frequent and tunnels occur. In general the tone is a medium grey due to the broken surface and shadows of the ballast. On clear photographs and those taken at a low altitude (5,000 ft.), the shadows cast by the rails are often seen.

(iii) *Telegraph poles.*—These almost invariably occur along a railway and frequently along roads in developed countries, but cannot be directly identified on a photograph except by their shadows. Strong sunlight and a suitable background are necessary to show them up. Telegraph lines may be identified by the shadows of the poles or by small spots indicating ground round each pole that has not been touched by cultivation. These shadows or spots will be at regular intervals and probably ranged in a series of straight lines.

(iv) *Bridges.*—These will be looked for at the crossings of roads, tracks, railways and water or at sharp dips in the ground. They are not always straight but generally uniform in width and probably cast a shadow. Most bridges have parapets, and the tops of these often appear as light grey or white lines as they are usually smooth. Outward projection of these parapets indicate the probable existence of piers.

(v) *Embankments and cuttings* are regular in shape, and can be identified by their shadows (fig. 5).



CHAPTER VII, FIG. 5.

If the slopes away from the light are in shadow they appear, of course, dark ; if not in shadow the angle of incidence of the light is so small that there is little chance of reflection towards the camera, and therefore they appear darker than the immediately surrounding ground, unless of such material as chalk. The slopes facing the sun, on the contrary, appear light grey or white, as the angle of incidence of the light is more favourable.

(vi) *Hills and depressions* (*quarries*).—The same considerations apply to rugged features as to embankments and cuttings, with the exception that they are usually of irregular shape. But in undulating country, slopes have no distinctive appearance, and the considerations discussed in para. 16 must be applied.

(vii) *Water.*—(*a*) Smooth water, except where it reflects the direct sun's rays into the camera (see para. 16) appears dark grey or black as it reflects only the indirect light from the sky. If the water is shallow, with a light bottom or weeds, the latter will reflect some light and the water appears lighter in colour. Thus, some idea of the depth of the water may be obtained. It is not easy to be sure whether mud or sand is covered by shallow water or exposed by low tide.

(*b*) Rough water, either sea or stream, presents innumerable reflecting faces to the light. Some light is then reflected into the camera with the result that white patches appear on the photograph. If water is ruffled by a light breeze these patches tend to appear in lines, whereas on a tumbling river or in surf the patches are irregular and cover a greater area.

(*c*) Streams and rivers never show straight lines unless embanked, and generally follow a tortuous, irregular path. There is little chance of confusing streams with any other feature.

(*d*) Canals are smooth-surfaced except when touched by a breeze, and appear dark grey or black. They are uniform in width and follow the contours. Frequently a towpath appears as a light line along one side. Locks may be identified by bars of light and shadow across the water.

(viii) *Trees, bushes, scrub and hedges.*—(*a*) These, with both reflecting surface and shadow, appear in shades from medium grey to black. Thus, a wood appears patchy—some trees reflecting more light than others and so tending to counteract the effect of colour and shadow. Isolated trees and bushes appear as circular dark spots at the end of slightly lighter shadows. These shadows assist in distinguishing clumps of trees from ponds and water generally. The stereoscope shows up trees unmistakably.

(*b*) Orchards are distinguished by the regularity in spacing of the trees.

(*c*) Scrub, usually mixed with grass or sand, appears as darker patches on a lighter tone. If the scrub is thick, shadows will be visible.

(*d*) Hedges appear as dark, irregular lines with or without shadow according to their height.

(ix) *Grass, heath and swamps* (*marsh*).—(*a*) Viewed from above, grass presents a broken surface reflecting little light. Its appearance, therefore, depends on colours and on its length and consequent shadow. Short grass appears lighter as it presents a better reflecting surface and may show the soil underneath. In general, grass is between light and medium grey and patches of coarse grass or heath are darker with a mottled appearance.

(*b*) Heath, merging into bog or marsh comprising irregular patches of water, is in darker shades of grey with the same mottled appearance.

(x) *Crops and general cultivation.*—(*a*) With all crops the same arguments apply as with grass; young crops appear a medium grey, ripening crops light grey. Such things as roots, beans, etc., presenting large leaves and corresponding shadows have a mottled appearance in medium or dark grey.

(*b*) Freshly ploughed land (and likewise fresh earth from excavations) presents a large proportion of flat surfaces to the light and therefore appears light. After harrowing, where surfaces are broken up, a darker shade is assumed. The nature of the soil decides the exact shade in each case; chalky soil always appears white, clay appears almost white when ploughed and darker soil a light grey.

(*c*) Heavily cultivated country appears as a mosaic or patchwork of varying shades and, except on large-scale photographs, it is difficult and frequently impossible to distinguish the nature of each patch of cultivation.

(xi) *Soil, sand and rocks.*—(*a*) In general, bare ground appears light, as do unmade roads. Chalky soil is indicated by white patches; clay is generally darker.

(*b*) Sand, providing a comparatively smooth surface, appears light; deeper-toned patches indicate slopes.

(*c*) Rocks vary from white to dark grey according to whether their surface is smooth or rough and broken. Wet rocks, facing the sun, reflect the light and appear white. Shadows are deep and well defined.

(xii) *Fences, ditches and walls.*—These are difficult to distinguish on photographs taken at usual heights, as the scale is not large enough to show them up. They may be found from their shadows when the sun is low. The stereoscope shows them up at once and differentiates one from the other.

(xiii) *Buildings.*—Owing to their flat surfaces, buildings generally produce high lights or at any rate light patches. Shadows are clear and well defined. Cottages are easily picked out after a little practice, but may be confused with haystacks.

The foregoing examples are hints, and only hints, on the photographic appearance of natural objects. There are two factors governing the appearance of objects which must always be borne in mind—time of day and season. The former gives the elevation of the sun and therefore the degree of reflection and extent of shadow to be expected. The latter controls the natural appearance (and, therefore, the photographic) of some objects, e.g., in parts of the world rivers only hold water at certain seasons, and therefore will appear black when with water, or light grey to white, depending on nature of bed, when dry.

18. Where the nature, or even existence, of a particular feature is in doubt, other and overlapping photographs of the same area will help, not only stereoscopically, but because of the different point of view. Paths or streams in forest country are most visible, for example, where they run to or from the centre of the photograph. They may be clearly distinguishable in this case although hard to find on another photograph.

19. *Limitation by scale.*—Many objects will be too small to appear on a photograph of comparatively small scale, and a sense of proportion must, therefore, be exercised. On a scale of 3 in. to 1 mile—an average scale—1 ft. is represented by about 1/2,000 of an inch.

20. *Indications of height.*—As before stated, single verticals afford no direct evidence of height. They do afford many clues to it, however. Thus, roads and railways are graded.

If a road or railway lies in a cutting it is crossing a spur or running up and down a convex slope. If on an embankment it will be running across a stream line or up and down a concave slope. On a sharp hillside lynchette (or steep banks) show the top or bottom of fields and follow the general line of a contour. Sheep or cattle-tracks take an easily graded line up and down hills. In vine country, Central and Southern Europe, Palestine, etc., walls between fields follow the contour more or less, whilst in tropical Asia paddy fields (always arranged for irrigation) also follow the contour. Lines of plough are not a reliable guide because they allow of drainage in one or other direction. Shadow may show up sharp slopes, and may give some grasp of tactical feature, but is of more value in estimating the size of banks, cuttings or hedges. To estimate heights in this way it is necessary to have a rough idea of the heights of the cottages and trees in that particular neighbourhood or of the width of road or permanent way upon which the shadow is cast. The most certain clue, however, is that afforded by the drainage, or rivers or streams, by which water is carried away.

21. *Mosaics.*—Mosaics will rarely be available on service. They are particularly useful either for the attack or defence of towns, villages or strong points. Mosaics are particularly difficult to make, and unreliable when made in hilly country, but even in flat country they should not be relied upon for distance or bearing. It is advisable to draw the map grid on the mosaic by inspection.

22. *Stereoscopic pairs.*—Since an overlap of 60 per cent. between successive prints is always allowed for, it is possible to examine the whole of the ground stereoscopically, and it is only in this way that the full value of the photographs can be obtained. Generally speaking, the effect of height is emphasised so as to make the vertical scale two or three times the horizontal (the further apart the two points of exposure are in the air the more is the height scale exaggerated). Before estimating heights, then, a rough figure for the heights of hills from the bottoms of valleys should be obtained from the map. Intermediate heights can then be estimated and the size and importance of obstacles gauged. The ordinary rules of lighting, of colour tone and of reflection, apply in stereoscopic as in single print examination, but it is far easier to identify the actual feature of the ground or the purpose of any artificial work, stereoscopically than otherwise.

23. *Negative marks.*—These occur sometimes and must not be confused with details of the ground. They are usually scratches or marks of dried drops of liquid on the negative. If any doubt exists as to whether an object exists on the ground or is a mark on the negative, compare the photograph with another which includes that portion of the country.

CHAPTER VIII

TRAINING OF PHOTOGRAPHIC PERSONNEL

General

1. All photographic personnel, both officers and airmen, are trained at the School of Photography, South Farnborough. A sound initial training is essential for all ranks employed on photographic duties.

All airmen photographers are required to pass through the school either as aircrafthands or as boy entrants, and to pass the various tests laid down before being posted to service units.

Senior N.C.O.'s and Warrant Officers who are required to take charge of photographic work in units are required to pass an instructor's course. Officers who are employed as photographic specialists are required to pass the specialist photographic course.

2. It is essential that, on posting to units from the School of Photography, airmen photographers should be given constant practice in all branches of their work. If this is not done, the training given by the School of Photography is wasted through lack of practical application of the airmen's theoretical knowledge.

Unit Training of Airman Photographers

3. A squadron photographic section is, however, but one link in the technical organisation which enables a squadron satisfactorily to perform its various duties. It exists, primarily, for the purpose of carrying out the ground work required in connection with the air photography performed by the flying personnel. The amount and nature of the work depends very largely on the nature of the squadron's activities from time to time.

4. In view of this, it is impossible to prescribe any definite training scheme for photographers employed in unit sections. If the amount of air photography which is undertaken by the squadron is sufficient, and if it is carried out more or less continuously throughout the year, no special training excercises will be necessary for the ground personnel, as they will obtain ample practice and experience in the course of their normal

duties. But if it happens that, owing to bad weather, or to pressure of other work, long periods occur during which little or no air photography is carried out, it is then the duty of the squadron commander and the photographic instructors concerned to devise some means of providing the airmen of the photographic section with adequate technical employment. This is best done by instituting a series of training exercises, any of which can be carried out, not in accordance with a set programme, but at any time at the discretion of the photographic instructor.

5. The photographic instructor is responsible for the training of all photographic personnel in the section of which he is in charge. He must ensure that all airmen have ample practice in all branches of their work and are given ample opportunity of preparing themselves for examinations for reclassification. In this connection it will be necessary for him to give certain airmen instruction in the theoretical as well as the practical side of their work.

CHAPTER IX

PHOTOGRAPHIC TRAINING OF FLYING PERSONNEL

General

1. In each squadron which is required to carry out air photography, every pilot, observer, and air gunner should be capable of undertaking a photographic flight as a part of his normal duties. The entire responsibility for the actual taking of air photographs rests with the crew of the aircraft. Carefully designed equipment, and an efficient ground organisation are both valueless unless the flying personnel are capable of performing this first operation successfully.

2. To do this, two things are necessary. First, the pilot must be able to fly the aeroplane accurately, and secondly the camera operator must be able to operate the camera correctly and be capable of remedying simple faults in the mechanism while in the air. These are not difficult operations, but those concerned require preliminary instruction in the correct methods of carrying them out, and then careful practice in such methods, before they can be undertaken with any certainty of success. As it is neither possible nor desirable to give every officer and air gunner a course of instruction at the School of Photography, this training must, therefore, be carried out by squadrons.

3. It is the duty of area and group photography officers, after consultation with those branches of the staff responsible for other forms of training, and with the approval of the area or group commander, to draw up programmes of annual photographic training for the units under their control. Squadron commanders must allot a portion of the individual training period for the purpose of carrying out these programmes, and are responsible that the personnel under their command attain the required degree of proficiency. Care must be taken, however, not to confine the performance of air practices to any fixed periods or dates during the individual training season. Photography is dependent, more than any other form of air work, on weather conditions, and unless the training programme is made elastic so that advantage may be taken of spells of fine weather whenever they occur, it will usually be found impossible to carry out as many flights as

are necessary. This procedure is simplified by the fact that a camera can be carried on almost any flight, and air photography practices can be carried out without inconvenience in conjunction with other forms of air training.

4. Photographic training will be divided into two portions, ground lessons and demonstrations, and practical air exercises. The photographic instructor is responsible to the C.O. of the unit for the photographic training of the flying personnel. He should give all the necessary instruction and detail the air work practices. A careful record of the progress of each individual must be kept and every endeavour made to assist pilots and air gunners to overcome any difficulties which they may experience. This is best done by examining the results of air practices with the crew responsible pointing out mistakes and explaining the causes and remedies. No results should be filed until they have been seen by the crew responsible, and the causes of any errors has been explained. The closest co-operation between the members of the crew is essential and both pilots and air gunners should have a knowledge of the duties, during a photographic flight, of the other member of the crew. This knowledge will enable them to appreciate each others difficulties and will lead to better co-operation.

Ground Training

5. Ground training will consist of a series of lectures and demonstrations and the syllabus should include the following :—

(i) Values and aims of air photography.

(ii) *Cameras and mountings.*

- (*a*) Description.
- (*b*) Methods of operation.
- (*c*) Changing magazines.
- (*d*) Method of levelling and setting for drift.
- (*e*) Possible failures and methods of remedying them. *See* para. 77, A.P. 1403, Camera, Aircraft, Type F. 24. Handbook.
- (*f*) Installation.
- (*g*) Testing camera after installation.
- (*h*) Method of holding camera for oblique photography.

(iii) *Calculations for air photography.*

- (*a*) Area covered.
- (*b*) Time interval and overlap.
- (*c*) Scale.
- (*d*) Marking maps before flight.

(iv) *Photographic flying.*

Vertical photography.

Pin points.
Overlaps.
Mosaics.
Methods of approaching start points.
Method of maintaining course, height, speed, and levels.
Instruments.
Finding drift and applying it to track and to camera.
Drifts sights.

Oblique photography.

Method of flying for hand-held oblique pin points.
Fixed obliques. Use of data in Appendix III., A.P. 1354. Method of flying and sighting.

Air Training

6. Air training consists of the practical application of the principles learnt during the ground instruction. Definite practices should be laid down, and these should be carried out as many times as are necessary until those concerned attain the required standard of proficiency. Practices should include vertical and oblique photographs of pin-points, straight runs of overlapping vertical photographs, and small mosaic photographs made up of a number of runs overlapping laterally. The standard which should be attained during the first year of training is given below. Advanced practices which necessitate a higher standard of skill may be laid down for trained pilots and air gunners with a view to meeting the special needs of different types of squadrons. All air practices should be marked and the marks obtained entered in the training record.

7. *Standard to be attained in first year.*

(i) *Pin-points.*

(*a*) *Vertical.*—In one flight, at a given height not below 3,000 ft., photograph successfully a number of pre-arranged pin-points. The number of exposures allowed should not be more than 25 per cent. greater than the number of pin-points. The standard of accuracy required is as follows :—

Focal length of lens used.	*Maximum permissible distance of pin-points from centre of negative.*
5-in. lens. } 6-in. lens. }	½ in.
Other lens.	1 in.

(*b*) *Oblique.*—In one flight at a height between 500 and 1,500 ft., photograph successfully a number of pre-arranged pin-points. The number of exposures allowed should be not more than 25 per cent. greater than the number of pin-points. Standard of accuracy required :—Image must be perfectly sharp all over, and subject must appear not more than 1 in. from centre of negative.

(ii) *Vertical overlaps.*

(*a*) *Cross country overlaps.*—In one flight make two overlaps of at least 12 exposures, each between given pin-points: the two tracks to vary by between 45° and 135° from each other. Standard required :—The line joining the pin-points must not deviate by more than 1 inch from the line joining centres of photographs. Overlap to be between 55 and 65 per cent. throughout.

(*b*) *Feature line overlaps.*—Make an overlap of a ground feature entailing at least two changes of course and 12 exposures. Standard required: Feature to be within 1 inch of centre of photographs and overlap between 55 and 65 per cent. throughout.

(iii) *Mosaics.*—In one flight make a mosaic of a given area which involves not less than three runs of 8 exposures each. Standard required :—Area to be covered without gaps, fore and aft overlap is to be between 55 and 65 per cent. and lateral overlap between 20 and 40 per cent. throughout.

(iv) *Fixed oblique overlap.*—Make a fixed oblique overlap of a line between two given points. The focal length of lens and angle of depression to be used to be decided by the photographic instructor. Standard required :—The line joining the pin-points to be within ¾ inch of the centre line of each photograph and the overlap along the line joining the pin-points to be between 30 and 60 per cent.

8. Air practices should be carried out by pilots and observers, or air gunners, on different flights. A pilot and an air gunner should not both be allowed to qualify in any practice on one set of results only. On no account may airman photographers be employed in the air as camera operators in connection with training practices. All calculations necessary for air practices should be made by the crew concerned. In order to avoid

complaints of low flying standard pin points and overlaps for oblique photography should be selected by unit commanders and should always be used for training practices.

8A. (i) When deciding upon the height at which any photography is to be carried out it must be remembered that, for a given ground speed and time of exposure, there is a minimum height from which sharp photographs can be obtained This limitation is due to the relative movement of the camera and the ground.

The minimum height from which a standard of definition equivalent to a circle of confusion of 1/200 in. diameter is obtainable is calculated from the formula :—

$$H = V \times T \times F \times 200.$$

where H = minimum height in feet.

V = ground speed in feet per second.

T = time of exposure in seconds.

F + focal length of lens in inches.

(ii) Photography should never be attempted below this minimum height unless the photographs are urgently required and prevailing conditions prevent the attainment of the necessary height. In such a case the photographs will not be critically sharp.

(iii) In the case of oblique photographs the distance " H " will be the distance from the aircraft to the nearest point on the ground which appears in the photograph.

9. On completion of a photographic air practice those members of the crew of the aircraft who are concerned should proceed to the photographic section immediately after landing, fill up a reconnaissance report, and ascertain from the photographic instructor, or from the N.C.O. in charge, when the results will be ready. They should again visit the section at the time stated, when they will be shown the results and receive the criticism and advice of the photographic instructor. Pilots should invariably be shown the results of all photography carried out during their own flights, in order that they may see, and so be able to correct, any errors in their photographic flying.

Photographic Reconnaissance Reports

10. Photographic reconnaissance reports are to be made out for all flights on which a camera is carried, whatever the object of the photography. A specimen report form is shown in Appendix I.

11. Whenever a camera is issued, a photographic reconnaissance report, filled in as far as possible, will be issued with the camera. Immediately after landing the camera operator will

fill in the details of the work carried out and the weather conditions, and make a note of any deviations from normal procedure, such as flying an extra strip to fill in a suspected gap, or camera failure, in the space allotted for remarks. He and the pilot will sign the report and return it together with the exposed magazines to the photographic section.

In army co-operation squadrons, after the films have been developed and printed, the reconnaissance report will be forwarded with the rough prints to the A.L.O. who will enter his remarks in the column provided. The report will then be returned to the photographic section for action and filing.

12. Reconnaissance reports will invariably be required by A.L.O.'s and others under war conditions, and it is, therefore, very desirable that all concerned should become thoroughly accustomed to preparing them. They are also of assistance when using photographs for the making or revision of maps, and a copy of the reconnaissance report should accompany prints produced for this purpose. In addition, they form a valuable record of tasks performed, and of the working of cameras.

Training Records

13. A careful record should be kept in all unit photographic sections of the progress and results of photographic training. This record should take the form of a chart as illustrated. Each lecture in the ground training syllabus should be numbered, and the date on which the lecture was attended should be entered opposite the names of the individuals attending, and under the appropriate lecture number. At the conclusion of the training season a written examination should be set, the marks obtained by each individual being entered in the column provided.

No. 999 (BOMBER) SQUADRON

INDIVIDUAL TRAINING RECORD—1934 TO 1935

Flight.	Name.	Ground Training. Lecture No. 1.	2.	3.	4.	5.	Written Exam.	Air Practices. Vert. p.p.	Vert. O/Ls.	Mosaics.	Obl. p.p.	Obl. O/Lap.
"A"	F/Lt. Smith ..	1.9.1935					70%	60, 72	60, 58, 65.	55	75	60, 68
"B"												
"C"												

14. Prints made from training negatives should be filed separately for each individual, the name of the person taking the photograph, date of exposure, and any other necessary details being marked on the back. Wallets, Probate (Sec. 14B, Ref. No. 291) form a convenient means of filing such prints.

APPENDIX I

ALLOCATION OF DUTIES IN CONNECTION WITH AIR PHOTOGRAPHY

1. The following instructions are promulgated for the guidance of officers and airmen employed on photographic duties.

2. *Duties of Command Photography Officer.*—(i) The command photography officer is responsible :—

(*a*) That the photographic work of the units and formations in the command is organised in accordance with the principles laid down in this manual.

(*b*) That the programme of photographic training in the Command is prepared in accordance with the existing regulations, and that it is so arranged, in view of the prevailing circumstances, as to ensure that the required standard of proficiency is maintained.

(ii) He should act as technical adviser to the A.O.C. in all matters relating to air photography.

(iii) His duties will be, primarily, of an administrative nature, but he will be required to possess a high standard of technical photographic knowledge, and should have considerable practical experience in air photography.

3. *Duties of Group Photography Officer.*—(i) The group photography officer is responsible that the photographic work of the units in the group is organised in accordance with the principles laid down in this manual.

(ii) He should act as technical adviser to the group commander, and will afford technical advice and assistance to the units in the group in all matters relating to air photography.

(iii) His duties will be both of an administrative and technical nature, and he will be required to possess a high standard of photographic knowledge and experience.

4. *Responsibility of C.O.*—(i) It is the responsibility of every C.O. to ensure that the photographic section of the unit, or station, is efficiently organised, and that sufficient trained personnel is available for the work.

(ii) C.Os. should inspect photographic sections at least once a week. During this inspection, special attention should be paid to the dark rooms, work rooms and equipment, and to the state of the photographic records.

(iii) The C.O. is responsible that no improper use is made of the dark rooms, or of photographic equipment and materials. In no circumstances will work of a private nature be permitted in a section, nor will any privately owned cameras, equipment, or materials be allowed to be kept on the premises.

(iv) The photographic instructor in charge of the section will advise his C.O. on all technical matters relating to photography.

(v) The C.O. of every unit is responsible for all photographic duties which involve flying, and should issue or approve all orders regarding the carrying out of photography in the air.

Appendix I

5. *Duties of Photographic Instructor i/c Section.*—The photographic instructor in charge of the section is responsible to his C.O. for the organisation and technical supervision of the work of the section. Where the section is organised on a station basis the senior photographic instructor will be in charge of the section. He will advise his C.O. on all technical questions relating to air photography.

(ii) He is responsible—

(*a*) For the organisation of all ground work in connection with photography, and for the discipline of the personnel.

(*b*) That the section is organised in accordance with the principles laid down in Air Publication 1354.

(*c*) That the marking, filing, and storage of negatives is carried out in accordance with the existing regulations, and that the records of photographs taken by the unit are kept in a proper manner and up-to-date.

(*d*) That all necessary cameras and equipment are held by the unit, and that such cameras and equipment are in a serviceable condition. For this purpose he will keep in close touch with the unit stores officer, and will co-operate with the latter, ensuring that all repairable cameras and articles of photographic equipment are returned to the appropriate depôt as soon as they become unserviceable.

(*e*) That the photographic organisation of the command or group so far as it applies to the unit, is strictly adhered to.

(*f*) For the technical training of the personnel of the photographic section, and for the training of the flying personnel of the unit in performance of photographic duties in the air.

(*g*) That no improper use is made of the dark rooms, or of photographic equipment and materials. In no circumstances will work of a private nature be permitted in a section, nor will any privately owned cameras, equipment, or materials be allowed to be kept on the premises.

(iii) He should ensure that all photographic accessories in aircraft are fitted in the correct manner, and will co-operate with flight commanders in ensuring that any modifications to aircraft necessitated by new designs of cameras or equipment are carried out as and when ordered. He will investigate at once any camera failures, and will take steps to remedy any defects, or to return the camera for repair without delay.

(iv) He should inspect periodically all photographic equipment, particularly any which may be in stores and not in constant use. He is responsible that all stocks of chemicals and sensitive materials are stored in a place suitable as regards temperature, moisture, etc., and will advise the unit stores officer with regard to the best means of maintaining in good condition such stocks as are kept in a unit store.

APPENDIX II

A List of Principal Air Ministry Orders and Air Publications Relating to Air Photography.

(1) Air Ministry Orders.

A.M.O. A.760/29. Carrying of private cameras in Service aircraft.

A.M.O. A.130/31. Reports on Service trials of equipment.

A.M.O. A.62/35. Photographic prints, etc.—issue on repayment.

A.M.O. A.113/35. Distribution and Co-ordination of Technical information and Orders.

A.M.O. A.208/37. The Classification, Fitting, Registration, Storage and Disposal of Photographic Negatives and Prints (as amended by A.M.O.'s A.361/38, A.76/39, A.309/39).

A.M.O. A.184/38. Photographic N.C.O.'s qualifications.

(2) Air Publications	A.P. No.
Photographic Equipment Manuals (Vols. 1 and 2)	1355
Interpretation of Air Photographs (Vol. 1)	1356
Photographic Tasks for which Squadrons of the R.A.F. are to be trained (A.S.M. No. 58)	1633
Royal Air Force Equipment Regulations	830
R.A.F. Manual of Army Co-operation	1176
R.A.F. Pocket Book	1087
Care and Maintenance of accumulators	1326
Priced Vocabulary of Stores	1086 (Part 4).

DATA FOR FIXED OVERLAPPING OBLIQUES

A.—Distances on the ground in feet represented by the near side of the film for various tilts of the camera.

B.—Distances of the line on the ground represented by the near side of the film from the point vertically below the aircraft.

C.—Distance in feet from the point where the axis of the lens prolonged will cut the ground and the plumb point.

Height in feet. (*Note.*—other heights will be in direct proportion).	Tilts from Horizontal.														
	A. Lateral width in feet.					B. Distances from plumb point to near side of photograph (in feet).					C. Axial distance from plumb point (in feet).				
						Six inch lens on 5″ by 5″ film.									
	15°	20°	22½°	25°	30°	15°	20°	22½°	25°	30°	15°	20°	22½°	25°	30°
500	630	568	542	520	484	649	543	496	456	382	1,866	1,373	1,200	1,072	866
1,000	1,260	1,136	1,083	1,041	968	1,298	1,087	992	912	764	3,732	2,747	2,400	2,144	1,732
						Eight inch lens on 5″ by 5″ film.									
	15°	17½°	20°	25°	30°	15°	17½°	20°	25°	30°	15°	17½°	20°	25°	30°
500	557	524	491	443	405	789	722	655	548	460	1,866	1,600	1,373	1,072	866
1,000	1,115	1,048	983	885	811	1,579	1,444	1,310	1,097	921	3,732	3,201	2,747	2,144	1,732

(50253) Wt. 4475/3611 2000 1/40 Hw. G.371 (T.S.447) S.O. Code No. 22-97-o-39